

UNCLASSIFIED

AD NUMBER
ADB025764
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; Feb 1978. Other requests shall be referred to Air Force Geophysics Lab., Hanscom AFB, MA 01731.
AUTHORITY
Per DoDD 5200.20

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS ~~BEEN~~ DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

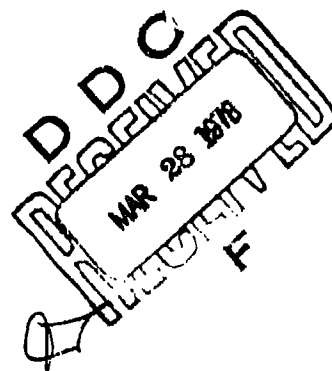
✓
AFFTC-TR-77-42

②
AFFTC-TR-77-42

AIR-LAUNCHED BALLOON SYSTEM



FINAL REPORT
FEBRUARY 1978



DISTRIBUTION LIMITED TO U. S. GOVERNMENT AGENCIES ONLY
(TEST AND EVALUATION), FEBRUARY 1978. OTHER REQUESTS FOR
THIS DOCUMENT MUST BE REFERRED TO:
AIR FORCE GEOPHYSICS LABORATORY,
AEROSPACE INSTRUMENTATION DIVISION,
BALLON REASEARCH BRANCH (LCB)
HANS COM AFB, MASSACHUSETTS 01731

CONTROLLING OFFICE: LCB

AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

No. FILE COPY

AD B025764

This technical report was submitted under Job Order Number 6665AO by the Deputy Commander for Operations of the Air Force Flight Test Center, Edwards AFB, California 93523.

Foreign announcement and dissemination by the Defense Documentation Center are not authorized because of technology restrictions of the U.S. Export Control Acts as implemented by AFR 400-10.

Prepared by:

This report has been reviewed
and is approved for publication:

Michael R. Wuest

MICHAEL R. WUEST
Project Engineer

William T. Twining

WILLIAM T. TWINTING
Colonel, USAF
Deputy Commander for Operations

Warren N. Massey

WARREN N. MASSEY
Project Engineer

John S. Burklund

JOHN S. BURKLUND
Colonel, USAF
Vice Commander

Qualified requestors may obtain copies of this report from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314. Department of Defense contractors must be established for DDC Services, or have "need to know" certified by cognizant military agency of their project or contract.

DDC release to NTIS is not authorized.

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or any other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Do not return this copy; retain or destroy.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFDTC-TR-77-42	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Air-Launched Balloon System	5. TYPE OF REPORT & PERIOD COVERED Final report 2 Feb - 17 Nov 77	
7. AUTHOR(s) Warren N. Massey Michael R. Wuest	6. PERFORMING ORG. REPORT NUMBER	
9. PERFORMING ORGANIZATION NAME AND ADDRESS 6511th Test Squadron (Parachute) National Parachute Test Range El Centro, CA 92243	8. CONTRACT OR GRANT NUMBER(s)	
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory, Aerospace Instru- mentation Division, Balloon Research Branch (LCB) Hanscom AFB, MA 01731	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	12. REPORT DATE Feb 1978	
	13. NUMBER OF PAGES 42 77P	
	15. SECURITY CLASS. (of this Report) UNCLASSIFIED	
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Distribution limited to U.S. Government agencies only (test and evaluation) February 1978. Other requests for this document must be referred to the controlling office for this report.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Aerial delivery system Balloon deployment system Radio relay deployment system		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This test program was conducted to investigate the feasibility of developing an air-launched balloon system which is eventually intended to carry a tactical communications relay to altitude when a ground launch of the system is not prac- tical. Fourteen airdrop tests were conducted from a C-130 aircraft at altitudes of 10,000 feet and 25,000 feet MSL and at an indicated airspeed of 130 knots. The test system weighed approximately 1500 pounds and operated in three stages: (1) extraction and descent under the extraction parachute, (2) deployment and		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

012 100

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Block 20, Contd.

descent under the recovery parachute, and (3) deployment and filling of the balloon. The test results indicated that the system developed is a feasible approach for air-launching a balloon system with some further development. When testing was terminated by the customer due to a shortage of balloons, time, and money, several problems still existed in the system. The first-stage suspension system components were susceptible to damage during the extraction phase of the test and the balloon inflation tube was susceptible to being choked off and bursting during the balloon-filling phase. ↑

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

PREFACE

The testing reported herein was requested by the Air Force Geophysics Laboratory (AFGL), USAF Cambridge Research Laboratory, Hanscom Field, Massachusetts in a letter dated 10 June 1976. This program was authorized by Air Force Flight Test Center (AFFTC) Project Directive No. 77-10 and documented as Job Order Number (JON) 6665AO. Testing began on 2 February 1977 and the customer terminated testing on 17 November 1977. This report constitutes closing action on this program.

ACCESSION for	
NHS	White Section <input type="checkbox"/>
DOC	Buff Section <input checked="" type="checkbox"/>
MANIPULATED	<input type="checkbox"/>
CLASSIFICATION	
BY	
DISTRIBUTION/AVAILABILITY CODES	
SPECIAL	
B	

TABLE OF CONTENTS

	Page No.
INTRODUCTION	5
Background	5
Purpose	5
Scope	5
TEST ITEM	5
Extraction Subsystem	6
Main Parachute Subsystem	6
Balloon Subsystem	6
Helium Subsystem	6
Container Subsystem	6
System Function	7
TEST SUPPORT EQUIPMENT	7
Aircraft	7
Forklift	7
DATA ACQUISITION AND PROCESSING	7
Test Data	7
Photo Coverage	10
Space Positioning	10
Instrumentation	10
TEST CONDITIONS AND PROCEDURES	10
Test Conditions	10
Parachute Packing Procedures	10
Balloon Packing Procedures	10
Rigging Procedures	10
In-flight Procedures	12
TEST RESULTS	12
Conclusions and Recommendations	23
APPENDIX A - Typical Force Traces	A1
APPENDIX B - 28-Ft D ₀ RS Parachute Packing Instructions	B1
APPENDIX C - 42-Ft D ₀ Ring Sail Parachute Packing Instructions	C1
APPENDIX D - Donut Bag Packing Instructions	D1
APPENDIX E - ALBS Rigging Instructions	E1
APPENDIX F - ALBS Rigging Components	F1
LIST OF ABBREVIATIONS AND SYMBOLS	24

LIST OF ILLUSTRATIONS

FIGURE No.	TITLE	PAGE No.
1	System Extraction	8
2	Descent Under 28-Ft Chute	9
3	42-Ft Chute Deployment	9
4	42-Ft Chute Partial Inflation	9
5	42-Ft Chute Full Inflation	9
6	Balloon Deployment	9
7	First Method of Apex Clevis Attachment	14
8	Second Method of Apex Clevis Attachment	15
9	Fouling of Balloon Deployment	17
10	Sheetmetal Fairing of the Pipe Framework Within the Box	18
11	No-Twist Linkage	19
A1	Extraction Chute vs Time	A1
A2	Recovery Chute vs Time	A2
B1	Step #1, Folding of Canopy	B3
B2	Step #2, Bag Attachment	B3
B3	Step #2, (Contd)	B4
B4	Step #3, Taped Connector L	B4
B5	Step #4, S-Folded Canopy in Deployment Bag	B5
B6	Step #4, Internal Flap Closure	B5
B7	Step #5, Black Clevis Attachment	B6
B8	Step #6, S-Folding Suspension Lines	B6
B9	Step #6, S-Folding 6-Legged Riser	B7
B10	Step #6, S-Folding Extraction Line	B7
B11	Step #8, Deployment Bag Closure	B8
B12	Step #9, Deployment Bag Safety Cord Attachment	B8
B13	Securing Bent V-Ring With Pendulum Cord	B9
C1	Steps #2 & #3, 20K-Lb Capacity (Black) Clevis Attachment on Centerline Apex	C3
C2	Apex Clevis Orientation	C3
C3	Step #4, Centerline Extension Installation	C4
C4	Step #5, Centerline Pulldown	C4
C5	Step #6, Canopy Roll-down	C5
C6	Step #7, Snood Close-Off	C5
C7	Step #8, 350-Lb BS Cotton Wabbing Tie From Snood to Apex Clevis	C6
C8	Step #9, Inflation Tube on Packing Table	C6
C9	Step #10, Inflation Tube Attachment	C7
C10	Step #12, Tying of Slack in Suspension Lines	C7
C11	Step #13, SS-2 Connection	C8
C12	Step #14, Placement of SS-2 Within Deployment Pack	C8
C13	Step #15, Folding of Inflation Tube Within Deployment Pack	C9
C14	Step #16, Stowing of Suspension System	C9
C15	Step #16, (Contd)	C10
C16	Step #17, First Canopy Fold	C10
C17	Step #18, Lanyard Attachment to Snood Cutters	C11
C18	Step #22, Deployment Pack Closure	C11
D1	Step #2, Installation of Attachment Straps	D4
D2	Step #2, Pencil Cutter Installation	D4
D3	Step #4, NTL Attachment	D5
D4	Step #6, Type III Nylon Cord Tie	D5
D5	Step #6, Filament Tape Attachment	D6
D6	Step #8, Attachment of Inflation Tube to Elbow	D6
D7	Step #8, Inflation Tube Sleeve Attachment	D7
D8	Step #10, Placement of Cover Over NTL	D7
D9	Step #10, Placement of Lower End Fitting Into Donut Bag	D8
D10	Step #11, Stowing Balloon	D8
D11	Step #12, Attachment of BDL to Upper End Fitting	D9
D12	Step #15, Lacing of Donut Bag	D9
D13	Step #15, (Contd)	D10
D14	Step #17, Center Tube Attachment	D10
D15	Steps #18 & #19, Cinch Tie and Lacing Lanyard Attachments	D11
D16	Step #20, Reefing Line Cutter Activation Lanyard Attachments	D11
D17	Steps #21, #22, and #23, Attaching Donut Pack to 42-Ft Do Ring Sail Chute	D12

LIST OF ILLUSTRATIONS, CONTD.

FIGURE No.	TITLE	PAGE No.
E1	Lowering System into Bag	E6
E2	Donut Bag and 42-Ft D ₀ Ring Sail Pack Restraint Tie Instal- lation	E6
E3	Preparation of Pull Knife	E7
E4	Donut Bag and 42-Ft D ₀ RS Parachute Pack Restraint Tie In- stallation	E7
E5	Placement of SS-1, RP-1, and MPDL on G-12 Clevis	E8
E6	Stretching SS-1 Over Box	E8
E7	Tacking SS-1 at 15K-Lb Capacity Connector Link	E9
E8	Tacking SS-1 at RP-1	E9
E9	80-Lb BS Cotton Tape Ties Between G-12 Clevis and Bar of Box .	E10
E10	Attachment of Inflation Tube to Gas Diffuser	E10
E11	RP-2 Attachment	E11
E12	Attachment of BDL to MPDL	E11
E13	Lacing-Pulling Lanyards Attached to 15K-Lb Capacity Connector Link on BDL	E12
E14	MPDL Foldback	E12
E15	Lanyard Attachments to MPDL	E13
E16	RP-1 Foldback	E13
E17	RP-1 Activation Lanyards	E14
F1-F4	ALBS Rigging Components	F3-F6

LIST OF TABLES

TABLE No.	TITLE	PAGE No.
1	Test Conditions	11
2	Test Results	21

INTRODUCTION

Background

The air-launched balloon system (ALBS) under development at AFGL is aimed at the requirement for a quick-reaction, lighter-than-air, tactical communications relay platform positioning capability. Operational planning calls for the system module to be extracted from a C-130 aircraft at 25,000 feet. When the system is properly deployed in mid-air, the stored ALBS balloon will be extended vertically and filled from a cryogenic helium storage unit. The balloon will then carry the communications relay to its assigned altitude (70,000 feet) while the inflation hardware floats to the ground by parachute.

Purpose

The purpose of this test program is to investigate the feasibility of an air-launched balloon system (ALBS). The development test and evaluation (DT&E) objectives are as follows:

1. To develop a test container, extraction system, recovery system, and balloon deployment system for an initial ALBS.
2. To acquire data and evaluate the suitability of the two-part container for airdrop and to evaluate the performance of the force transfer devices and parachutes during three-stage airdrop.
3. To determine and define any problems which may occur in this type of airdrop.
4. To develop and apply control methods, items, and rigging techniques to attempt to overcome any problems found with this system.

Scope

Fourteen airdrop tests were conducted from a C-130 aircraft at indicated airspeeds of 110 to 130 knots and at mean sea level (MSL) altitudes of 10,000 feet or 25,000 feet. The gross system weight ranged from 1473 to 1570 pounds. Displacements, velocities, accelerations, forces, event times, and photographic coverage were obtained on selected tests.

TEST ITEM

The test item was a multi-stage air-launched balloon system. Detailed component descriptions and final configuration packing and rigging instructions are contained in Appendix A. All major changes made in the system rigging which led to the final configuration are detailed in a test-by-

test discussion in Test Results. The major components of this system were an extraction parachute with drogue line, a main parachute, a balloon, a helium system, and a container.

Extraction Subsystem

The final configuration extraction subsystem consisted of a 28-foot D₀ ringslot parachute (28-foot chute) connected to a 200-foot-long drogue line and a deployment bag in which the 28-ft chute and drogue line were packed. In addition, there was a four-legged first-stage suspension sling (SS-1) with a Radioplane release device (RP-1) which connected the drogue line to the container subsystem. Also, there was a main parachute subsystem deployment line (MPDL) with a second Radioplane release device (RP-2) and a balloon subsystem deployment line (BDL) connected to the extraction line just above the second Radioplane release.

Main Parachute Subsystem

The main parachute subsystem consisted of a 42-foot D₀ ringsail parachute (42-foot chute, Pioneer Parachute Co., PN X7111018-1) with centerline, a balloon inflation tube that ran the full length of the 42-foot chute, a four-legged second-stage suspension sling (SS-2), an inner bag (snood) to control excess canopy slack created by the centerline prior to canopy inflation, and a main parachute deployment pack.

Balloon Subsystem

The balloon subsystem consisted of a 157,000-ft³ balloon, an upper end fitting to which the BDL was attached, a lower end fitting to which the inflation tube was attached, a no-twist linkage (NTL) connecting the lower end fitting to the apex of the 42-foot chute, and a donut pack for this subsystem. The donut pack was attached to the apex of the 42-foot chute.

Helium Subsystem

The helium subsystem consisted of two high-pressure helium bottles, high-pressure plumbing and regulator, low-pressure plumbing and regulator, an electric control valve and timer, and a diffuser to which the inflation tube was attached. The system contained enough helium for a 4% balloon inflation.

Container Subsystem

The container for these tests consisted of a 4x4x4-foot box constructed of a steel frame with plywood sides and bottom with the top face open. Suspension points were provided at the top four corners for attachment of

the first- and second-stage suspension slings. Into this box were placed the main parachute subsystem, balloon subsystem, an instrumentation pack and all associated hardware. The helium subsystem was attached to the under-surface of the box and protected with paper honeycomb crush material.

System Function

At drop initiation, the 28-foot chute deployment bag was released from the C-130 aircraft pendulum mechanism. The drogue line and then the 28-foot chute were pulled out of the deployment bag as it fell away from the aircraft and the 28-foot chute inflated and pulled the box out of the aircraft (time = 0 seconds, Figure 1). At T = 10 seconds, the box and extraction subsystem had stabilized in a vertical descent (Figure 2) under the 28-foot chute and Radioplane #1 fired, releasing first-stage suspension slings from the box. The box fell away and the main parachute deployment line pulled the 42-foot chute and the donut pack, attached to the apex of the 42-foot chute, out of the box (Figure 3) and the 42-foot chute began inflation (Figure 4). At T = 14 seconds, two reefing line cutters fired, allowing the snood to open releasing the excess canopy slack it had contained. The canopy of the 42-foot chute then completed inflation (Figure 5). At T = 16 seconds, four reefing line cutters fired, cutting the lacing holding the cover onto the donut pack. At T = 20 seconds, Radioplane #2 fired, releasing its attachment to the 42-foot chute apex through the main parachute deployment line, and the balloon deployment line pulled the balloon out of the donut pack (Figure 6). At T = 35 seconds, a valve in the helium subsystem opened and allowed helium gas to pass up the balloon inflation tube and into the balloon.

TEST SUPPORT EQUIPMENT

Aircraft

A C-130 aircraft was provided by the 6514th Test Squadron as drop aircraft. It was outfitted with a roller conveyor system and parachute pendulum release mechanism. A T-28 aircraft was provided by the National Parachute Test Range (NPTR) as photochase.

Forklift

A 10,000-pound-capacity forklift was used to transport the test item from the rigging area to the aircraft. The forklift was also used to position the box during rigging.

DATA ACQUISITION AND PROCESSING

Test Data

Test data were acquired by electronic and optical methods using a common 100 Hz binary coded time base. Event times, including load release (zero time), were determined by cinetheodolite film exposed at 5 frames per second or 35mm cameras using film exposed at 50 frames per second.

1. 28-FT CHUTE DEPLOYMENT BAG

2. 28-FT CHUTE

3. DROGUE LINE

4. MPDL

5. SS-1

6. RP-1

7. BOX

8. BDL

9. RP-2

10. DONUT PACK

11. SNOOD

12. 42-ft CHUTE

13. INFLATION TUBE

14. CENTERLINE

15. SWIVEL

16. BALLOON

17. NTL

18. HELIUM SYSTEM

19. SS-2

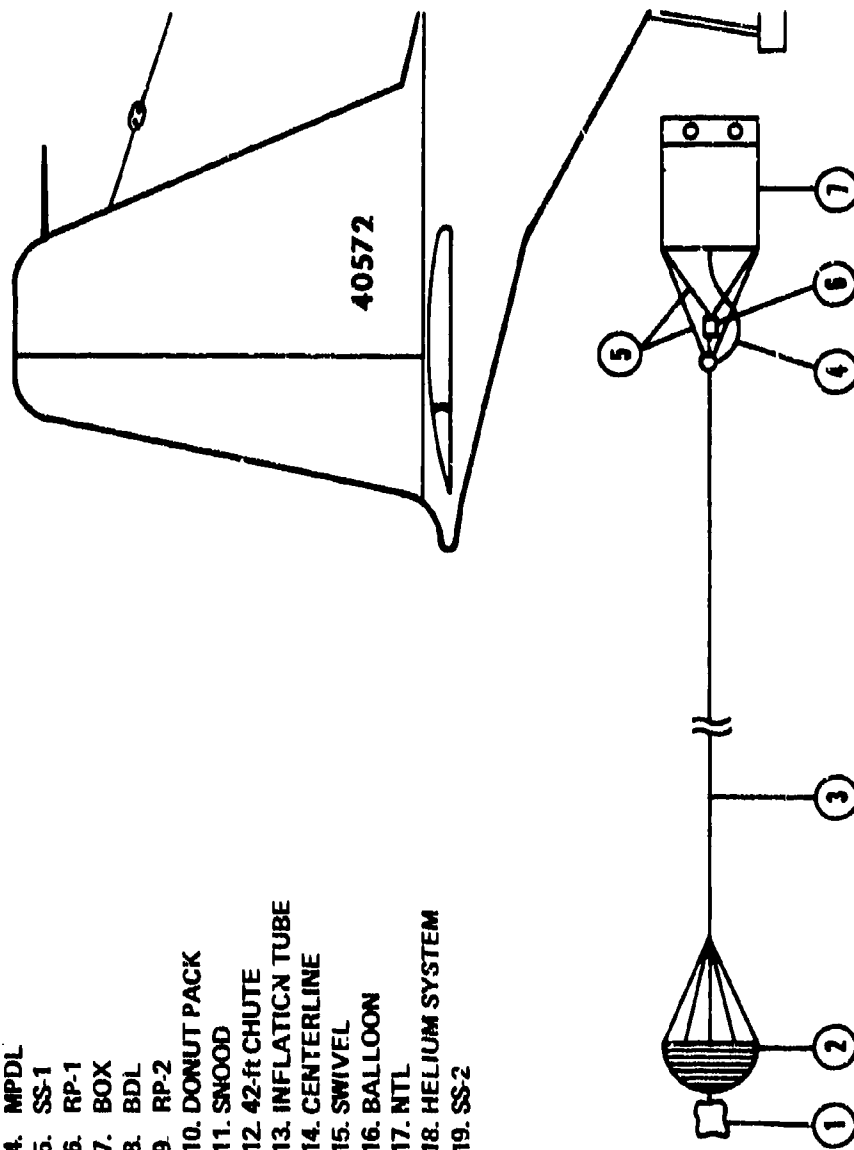


Figure 1. System Extraction.

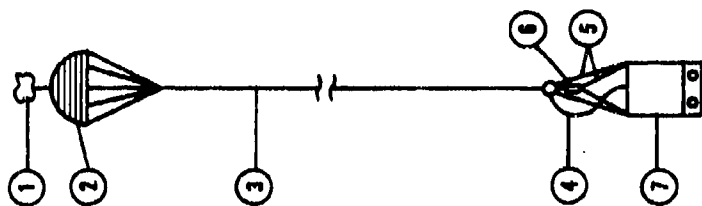


Figure 2
Descent Under
28-Ft Chute

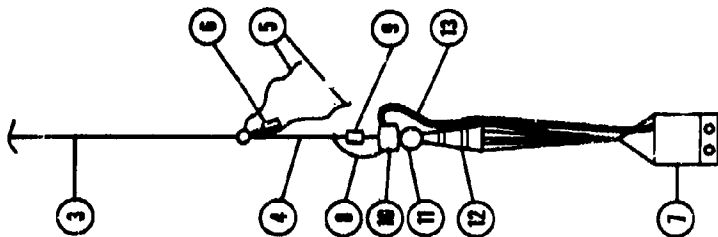


Figure 3
42-Ft Chute
Deployment

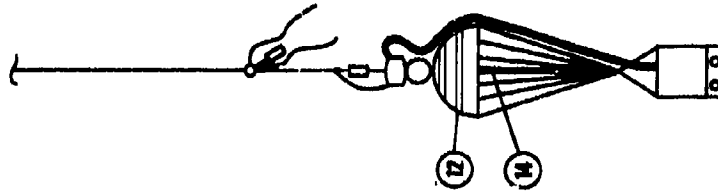


Figure 4
42-Ft Chute
Partial Inflation

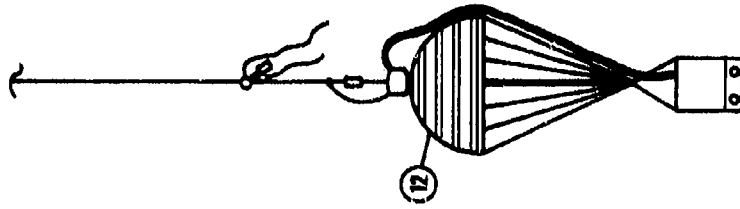


Figure 5
42-Ft Chute
Full Inflation

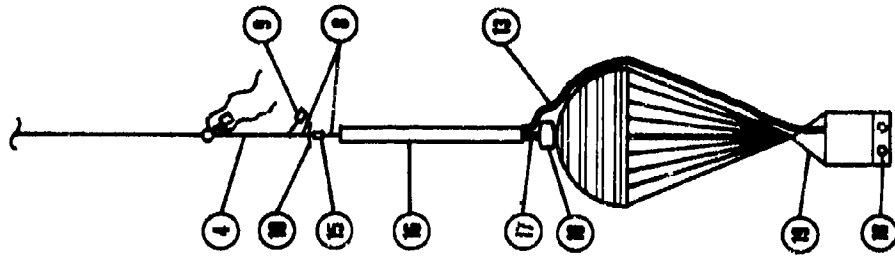


Figure 6
Balloon
Deployment

Photo Coverage

Hand-held plane-to-air, air to-air, and ground-to-air motion picture coverage was obtained using 16mm cameras. Color film was exposed at speeds ranging from 24 to 200 frames per second. Ground-to-air 70mm, 15 frames per second sequence stills were also obtained on selected tests. Still cameras were used to obtain rigging and damage photographs of the test system.

Space Positioning

Cinetheodolites with exposure rates of from 1 to 5 frames per second were used to determine sequential positions of the test system in space. From these positions, in conjunction with supplementary information, mean sea level (MSL) rate of descent, acceleration, dynamic pressure, and altitude loss were computed. The supplementary data were either surface wind measurements or Rawinsonde data. The Rawinsonde data provided wind velocity, atmospheric pressure, and air temperature at 1,000-foot increments up to launch altitude. Space positions were determined using film from a minimum of three cinetheodolite stations. Individual station azimuth and elevation readings were corrected for tracking error. All space positioning computations were performed using a Control Data Corporation Model 3300 Digital Computing System.

Instrumentation

On selected tests, the system was instrumented using strain links in the drogue line and just below the confluence point of the 42-foot chute. On another selected test, a $\pm 15g$ accelerometer was mounted within the box. The data acquired were telemetered to a ground recording station for post-test reduction and annotation.

TEST CONDITIONS AND PROCEDURES

Test Conditions

Table 1 presents the test conditions for this program. Individual tests are identified by test sequence number and by National Parachute Test Range (NPTR) Operations Directive Number (O.D. No.).

Parachute Packing Procedures

The packing procedures developed during this test program for the 28-foot chute and 42-foot chute are contained in Appendix B and Appendix C.

Balloon Packing Procedures

The packing procedures developed during this test program for the AFGL balloon are contained in Appendix D.

Rigging Procedures

The rigging procedures developed during this test program for the air-launched balloon system are contained in Appendix E.

Table 1

TEST CONDITIONS

Test No.	NP/R OD No.	Altitude MSL (ft)	Indicated airspeed (knots)	Gross system weight (lbs)	Test date	Remarks
1	382-77	10,357	130	1510	2-2-77	32-ft D ₀ ring slot extraction chute used
2	518-77	10,000	130	1500	3-29-77	Weight bomb test of 32-ft extraction chute
3	413-77	10,560	120	1506	4-8-77	28-ft D ₀ ring slot extraction chute used
4	420-77	10,360	120	1497	4-21-77	RP-1 & RP-2 initiated using pyrotechnic cartridges
5	611-77	10,140	120	1423	5-4-77	Reefing line cutters installed to cut donut lacing
6	663-77	10,000	130	1514	5-11-77	Pivot pins in RP-1 & RP-2 replaced with 3/8" bolts
7	612-77	25,000	130	1530	5-25-77	Apex clevis attachment and inflation tube routing changed
8	756-77	25,000	128	1530	6-17-77	600-lb break ties used on centerline
9	757-77	24,950	131	1524	6-29-77	Real balloon used
10	791-77	25,000	130	1555	7-7-77	Girdle bands attached to donut pack
11	826-77	25,000	130	1570	7-26-77	NTL and compressed gas helium system used
12	122-78	10,000	130	1539	10-27-77	Weight bomb coning test, 42-ft chute with centerline
13	123-78	10,000	130	1574	10-27-77	Weight bomb coning test, 42-ft chute without centerline
14	124-78	25,000	130	1534	10-27-77	Elbow added to balloon lower end fitting. Modified compressed gas helium system used. Modified connection between 42-ft chute and SS-2. Modified inflation tube sleeve.

In-Flight Procedures

Standard C-130 heavy airdrop procedures adapted for high altitude were used for the airdrop of this system.

TEST RESULTS

Data

Airdrop test results are presented in Table 2. Representative traces of the 28-foot chute extraction force and the 42-foot chute recovery force are contained in Appendix A.

Narratives of Individual Tests

Background

It is the intent of this report to show the system evolution and reasons for changes on a test-by-test basis. It is therefore necessary to begin with a description of the initial system and then note changes as they were made.

The major components of the initial system were: 32-foot D₀ ringslot extraction parachute (FDFRR-8-2); 200-foot drogue line; first-stage suspension slings; first-stage Radioplane release (which was electrically initiated from a timer mounted in the box); main parachute deployment line; second-stage Radioplane release (which was electrically initiated from a timer mounted on the donut pack; balloon deployment line; a 102-foot, 18-ply Type 26 nylon webbing riser (to simulate a balloon); a 42-foot D₀ ringsail parachute; snood; second-stage suspension slings; and the box.

Test #1

Upon extraction of the box from the aircraft, the 32-foot chute experienced suspension failure and broke away from the drogue line. As a result, the 42-foot chute was never deployed and the box and its contents impacted the ground at a high velocity. Post-test inspection of the parachute revealed that the 550-pound nylon cord suspension lines had broken in an area where they had previously been dyed. Tensile tests of similar lines confirmed a 21% reduction in strength in the dyed areas.

Test #2

This test was to check out the extraction of a 1500-pound weight bomb using a 32-foot chute modified with 750-pound nylon cord suspension lines, gore reinforcing tape sewn to reinforce dyed areas of the canopy skirt, and 560 inches canopy reefing for eight seconds. The 32-foot chute was attached to the weight bomb by the 200-foot drogue line. The parachute deployed normally but disreef occurred prematurely and the apex of the 32-foot chute canopy blew out.

Test #3

The major components of the system for this test were identical with Test #1, with the exception of the substitution of a 28-foot D₀ ringslot parachute for the 32-foot D₀ ringslot parachute. The box was extracted

from the aircraft and 20 seconds later, Radioplane #1 fired and the 42-foot chute was deployed from the box and inflated. Radioplane #2, which allows the extension of the dummy balloon, did not fire and the system descended to the ground. Post-test inspection of Radioplane #2 revealed that the wires between it and the timer mounted on the donut pack had been broken.

Test #4

The change to the system from Test #3 consisted of using 10-second pyrotechnic delays rather than 20-second electronic delays for Radioplane #1 and Radioplane #2. The change in timing was necessary because of the availability of the pyrotechnic delay cartridge. The box was extracted from the aircraft and 10 seconds later, Radioplane #1 fired, allowing the 42-foot chute to deploy and open. Again, the dummy balloon failed to extend and the system descended to the ground. Post-test inspection showed that Radioplane #2 had fired but that only one of the two pull knives used to cut the lacing holding the cover on the donut bag had cut completely through the lacing cord. The remaining pull knife only partially cut the lacing and did not let the system extend any further. The bottom of the donut bag incurred minor damage that was attributed to the sudden downward acceleration of the donut bag at centerline stretch during the deployment of the 42-foot chute.

Test #5

The change made to the system for this test was to use four each (two each side) lanyard-activated six-second reefing line cutters on the donut bag cover to cut the lacing. Also, the lacing lanyard was routed through metal rings where previously it went through nylon loops. During the extraction phase of this test, second-stage suspension slings prematurely released, forcibly pulling the 42-foot chute through the middle hole of the donut pack preventing the 42-foot chute from opening. The system descended to the ground under the 28-foot chute. Post-test inspection of the system revealed that Radioplane #1 had failed. The 3/3-inch pin on which the swing-pin pivots came out, allowing the swing-pin to be released from the radioplane release device.

Test #6

The change made for this test was to replace the 3/8-inch pins in Radioplane #1 and Radioplane #2 with 3/8-inch bolts and self-locking nuts. The system functioned properly for the extraction, 42-foot chute deployment and dummy balloon deployment phases. During system descent, the 42-foot chute and box coned at about a 30-degree included angle. Post-test inspection revealed burn and tear damage to first-stage suspension slings where they attached to the box and Radioplane #1. (R1)

Test #7

The apex clevis attachment was changed to allow the apex vent of the 42-foot chute to more fully open (see Figures 7 & 8) in an effort to reduce coning action. The inflation tube, which had previously been routed up the centerline of the 42-foot chute, was routed up a suspension line and over the top of the 42-foot chute canopy to the donut pack. This was necessary because it became apparent that the inflation tube could become entangled if routed up through the apex vent. A swivel was placed on the balloon deployment line to prevent rotation of the 28-foot chute from affecting the balloon. During the drop, all systems worked properly and the inflation tube

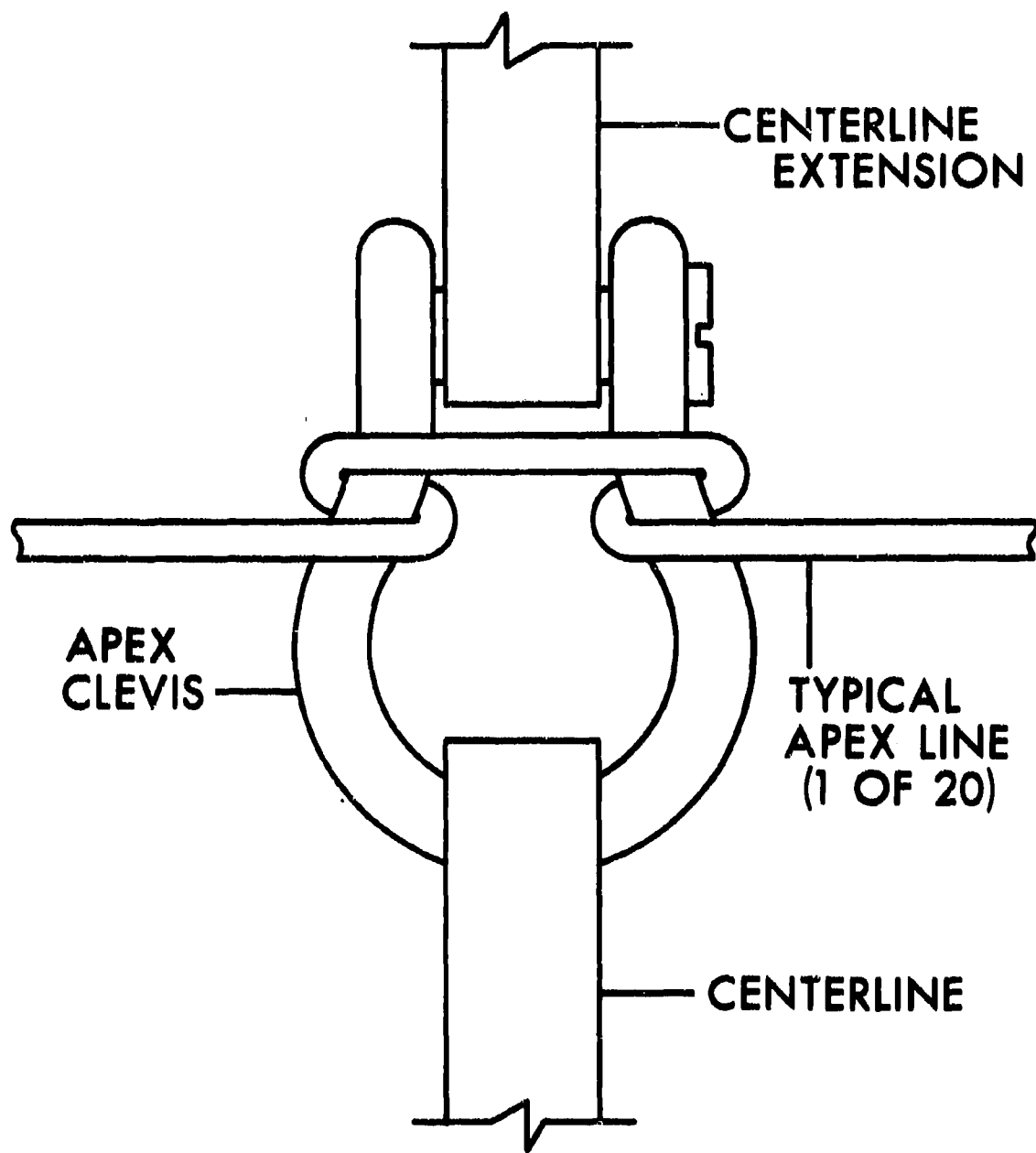


Figure 7. First Method Of Apex Clevis Attachment.

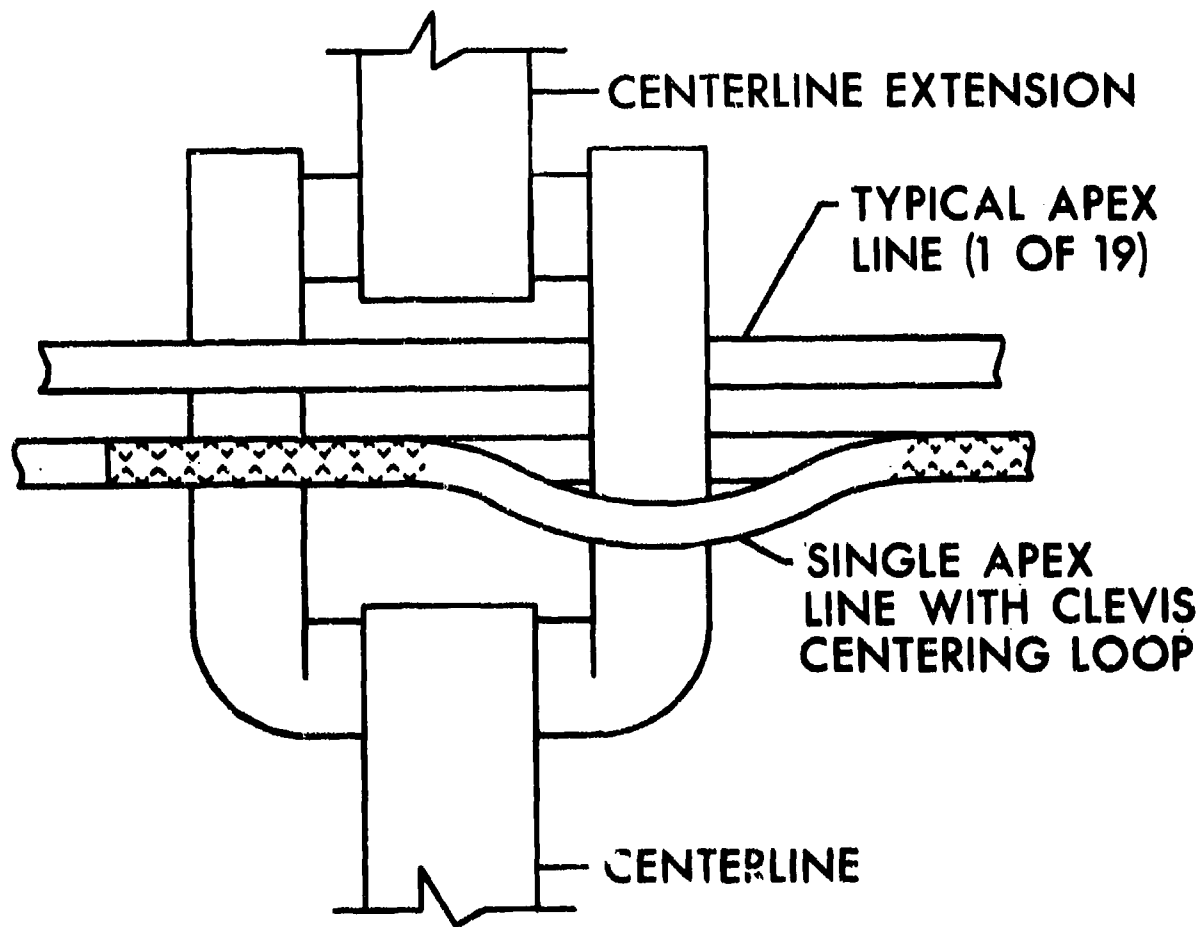


Figure 8. Second Method Of Apex Clevis Attachment.

was not damaged by the new routing. After the dummy balloon was extended, the system did exhibit coning at about the same included angle as before (approximately 30 degrees). The center of the donut bag was found to be torn after the test and this again was attributed to line stretch of the centerline during deployment of the 42-foot chute. First-stage suspension slings incurred burn and tear damage where it connected to the box and Radioplane #1. (R1)

Test #8

The only change made for this test was to saw 18 evenly-spaced nylon loops to the 42-foot chute centerline and install a steel eye in the bottom of the box. During the packing of the 42-foot chute, each of the loops was tied to the eye with one turn of 350-pound breaking strength cotton. The intent of this modification was that the 18 successive breaks of approximately 600 pounds would delay the 42-foot chute deployment enough to reduce the centerline line stretch force. During the drop, the system functioned properly, coning was still evident. Post-test inspection of the system showed first-stage suspension slings incurred burns where it connected to the box and nicks where it connected to Radioplane #1. Force traces showed no reduction in 42-foot chute centerline stretch force over forces recorded on previous tests so the centerline break ties were eliminated. (R1)

Test #9

The changes for this test were incorporation of a real AFGL balloon and a larger donut pack to accommodate the greater bulk of the balloon. During the test, the system worked properly up through the start of balloon deployment, but the balloon did not extend any further than approximately six feet. Post-test inspection of the system revealed that a loop of 1500-pound nylon used to control the donut pack bulk had slipped off of the pack and fouled the balloon (see Figure 9). Again, first-stage suspension slings were damaged at the box and Radioplane #1. (R1)

Test #10

The only changes made to the system for this test was the addition of four nylon girdle bands around the donut pack to help control pack bulk. The bands were held in place by four rows of loops running around the circumference of the pack. Sheetmetal was also used to fair-in the steel pipes on the inside of the box (see Figure 10) to prevent impacting the donut pack on a pipe during deployment. The system worked properly on this test. The balloon deployed properly. Post-test inspection of the system showed that the 28-foot chute deployment bag had broken the cotton loop at the apex of the 28-foot chute and had been lost. The inflation tube was twisted 2-1/2 times around the nylon attachment line which connects the balloon lower end fitting to the apex of the 42-foot chute. During an actual inflation, this would have choked off the helium supply to the balloon. First-stage suspension slings were damaged. (R1, R3)

Test #11

For this test, a special flexible connection was fabricated to connect the balloon lower end fitting to the apex of the 42-foot chute and yet not allow them to rotate relative to each other. This connection was called the no-twist linkage (NTL, Figure 11). This was the first test that employed a compressed gas helium system intended to provide a 3 to 4% inflation. The system functioned properly and approximately 10 seconds after the balloon was deployed, an elec-

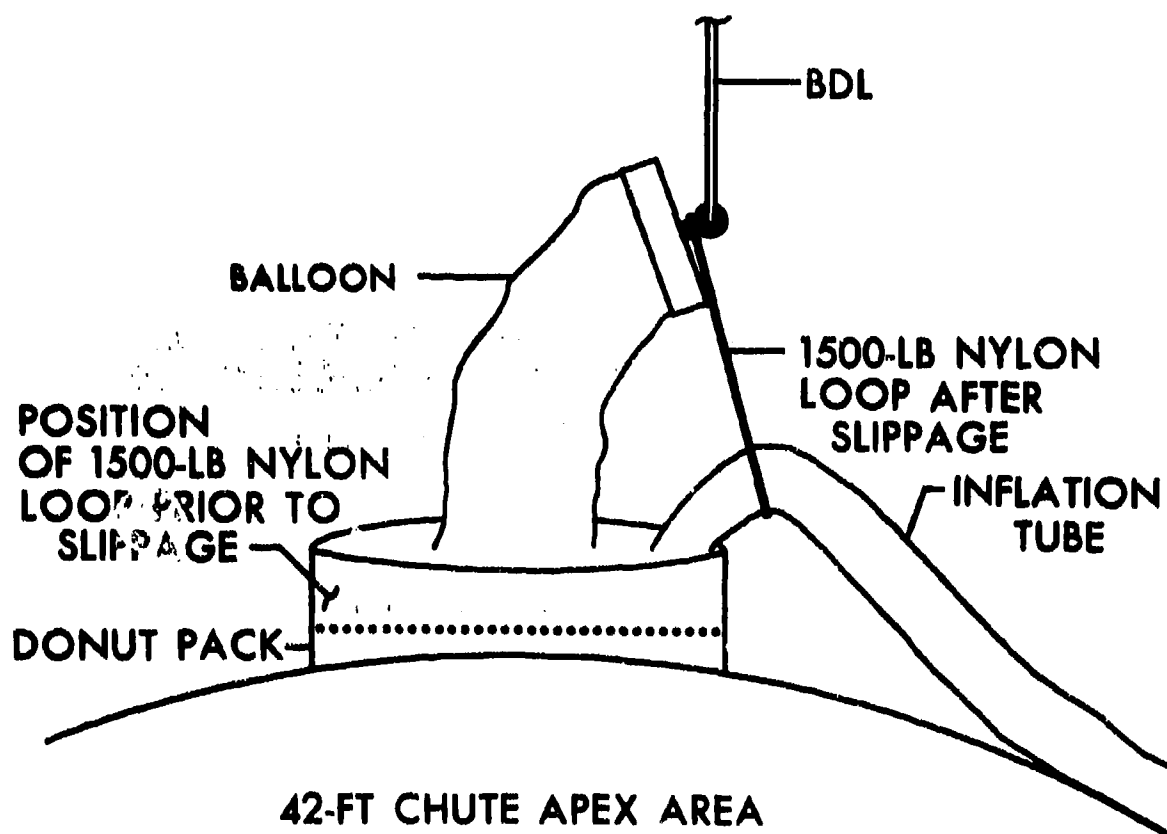


Figure 9. Fouling Of Balloon Deployment.

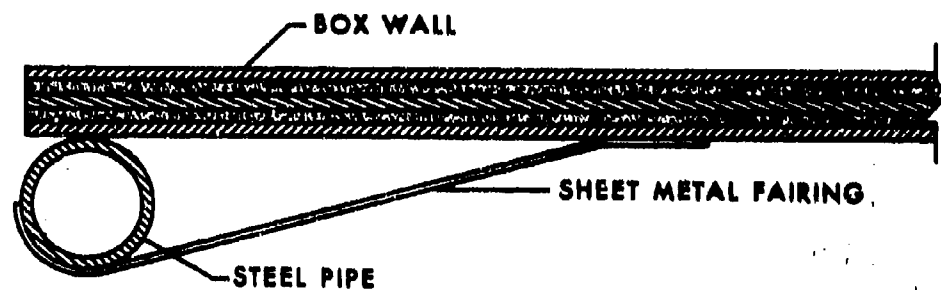


Figure 10. Sheet Metal Fairing Of The Pipe Framework Within The Box.



FIG. 11

NO-TWIST LINKAGE

trical timer caused a valve to be opened allowing helium into the inflation tube. No inflation of the balloon was apparent from the ground. Post-test inspection of the system revealed Radioplane #2 had impacted the balloon upper end fitting tearing a hole in the balloon plastic while the system was landing. As a result, no determination of whether or not helium had been in the balloon could be made. Inspection of the inflation tube revealed a five-foot section of the plastic tube with longitudinal splits approximately 6 feet beyond the point where the inflation tube attached to the helium system diffuser. Review of the film of the test indicated the possibility of a 3/4-turn of the inflation tube (in the area of the splits) around the junction of the 42-foot chute confluence point and second stage suspension slings. If this did indeed occur, the inflation tube could have been choked off sufficiently to cause a blow-out. It was also suspected and later confirmed by tests at the National Bureau of Standards, Denver, CO. Facility that a sudden step input of gas into the inflation tube will cause the tube to burst. The helium system used on this test does provide such a step input. First-stage suspension slings were again damaged both at the box and at Radioplane #1. (R1, R3)

Test #12

This was a test of a 1500-pound weight bomb and a single 42-foot chute with centerline to see if this simple system experienced coning. The system did cone and oscillate during descent to about the same degree as the full balloon system.

Test #13

This was a test of a 1500-pound weight bomb and a single 42-foot chute without centerline to see if the basic 42-foot chute experienced coning. Upon opening, 9 of the 40 suspension lines broke at a sewn keeper just above the confluence point. The damaged 42-foot chute remained open and recovered the weight bomb. Due to the failure of adjacent lines, considerable drift was noticed. The system did not cone but did exhibit other unstable motions due to the damage.

Test #14

This test was intended to be a repeat of Test #11 where a 3 to 4% balloon inflation was attempted. The helium system was modified to provide a gradual input rather than the previous step input of the helium gas into the inflation tube. The connection between the 42-foot chute confluence point and second-stage suspension slings was shortened to help prevent relative twisting between the box and 42-foot chute. The construction of the inflation tube sleeve was changed to allow for more slack along its length and to make the inner surface smoother for the plastic inflation tube to bear against. An elbow pipe attachment for the inflation tube was added to the balloon lower end fitting where a straight pipe attachment had been used previously. This was to prevent the inflation tube from being partially closed off due to the 90° bend required at this point. Three nonfunctioning items were added to the system, that would be required on future tests, to check their compatibility with the system. They were a Tenny release device and an explosive nut added to the no-twist linkage to insure that balloon/42-foot chute separation could be achieved and an 8-conductor electrical cable routed from the bottom of the box up and over the 42-foot chute to the balloon lower end fitting.

Table 2

TEST RESULTS

Test No.	WTR OD No.	Maximum Extraction chute force (lbs)	Maximum recovery chute force (lbs)	Maximum rate of descent under extraction chute (ft/sec)	Maximum rate of descent under recovery chute (ft/sec)	Remarks
1	382-77	19,240	(1)	(1)	(1)	32-ft chute failed during extraction
2	518-77	(2)	(2)	(2)	(2)	32-ft chute prematurely disreefed and failed during weight bomb extraction.
3	413-77	6,208	7,355	90	44	RP-2 failed to release, no dummy balloon extension.
4	420-77	7,418	6,929	90	45	Lacing on donut bag failed to be cut, no dummy balloon extension.
5	611-77	16,724	9,002	98	(1)	RP-1 failed, 42-ft chute did not open, system descended under 28-ft chute.
6	663-77	9,687	6,593	100	39	Coning action of full system observed.
7	612-77	(3)	(3)	116	51	Coning action of full system observed.
8	756-77	11,119	7,078	(2)	(2)	Coning action of full system observed.
9	757-77	12,468	(3)	(2)	(2)	Only partial extension of balloon due to fouling of system by nylon loop.
10	791-77	10,016	(3)	(2)	(2)	System coned, inflation tube twisted around connection between balloon lower end of fitting and apex of 42-ft chute.
11	826-77	11,631	6,589	(2)	(2)	No balloon inflation due to a tear in the inflation tube. System coned.
12	122-78	(2)	(2)	(2)	(2)	Weight bomb and 42-ft chute with centerline coned and oscillated.
13	123-78	(2)	(2)	(2)	(2)	Weight bomb and 42-ft chute without centerline broke 9 suspension lines.
14	124-78	(2)	(2)	(2)	(2)	RP-1 impacted the box and released prematurely, deploying 42-ft chute. Centerline and 4 suspension lines broke, 42-ft chute opened, balloon extended, no balloon fill due to extensive balloon damage incurred during malfunction.

FOOTNOTES

- 1 These data were not obtained for this test due to test system malfunction.
- 2 These data were not requested for this test.
- 3 These data were not obtained due to data acquisition system malfunction.

During the extraction phase of the test, the 42-foot chute prematurely deployed and opened approximately 10 seconds after extraction. The balloon properly extended and the helium system was turned on. Post-test inspection revealed RP-1 has been severed and lost from its attachment strap. The balloon had suffered major damage to the balloon plastic and to the lower end fitting. The 42-foot chute had a broken centerline, four broken suspension lines, and damage to some canopy panels. The plastic inflation tube had been split just below the balloon lower end fitting for a distance of approximately 15 feet. Within the box, the sheet metal which faired-in the pipes had shown signs of repeated hardware impact. Several of the impact marks matched the size and shape of a radioplane release device, so it was possible that RP-1 was pulled down into or recoiled into the box during deployment of the 28-foot chute. (R2)

DISCUSSION

1. It is felt that the inflation tube would be less susceptible to choking if it were not fastened to any point along its length except at each end. This would prevent the inflation tube from being twisted off due to rotation of the 42-foot chute relative to the balloon or helium storage system.
2. The balloon developed by AFGL for this program is of a new type with an internal inflation tube which connects to the external inflation tube at the lower end fitting. The internal tube runs up the length of the balloon and empties out near the upper end fitting. It would be desirable to try to inflate the balloon using the present length of external inflation tube and gas fill rate to see if the fabric of the balloon, in its sleeve, causes the internal inflation tube to be choked off.
3. Development of an enclosed ALBS for the extraction phase would be highly desirable to give protection to the box's contents.
4. It would be desirable to develop a system for releasing the drogue force at the box rather than letting it be released from an exposed release device. This would provide mutual protection for the release system and for the box and its contents. This could take the form of a suspension sling that had each of its legs released at their connection to the box or a load bar which has each of its ends released at the box or a load-carrying cover that is released along its edges.
5. It may be desirable to use stronger break ties on the stows of the 200-foot drogue line. The higher forces these breaks would produce would better insure that the 28-foot chute deployment bag mouth aligned itself facing the aircraft. This would make the deployment action of the drogue line and 28-foot chute smoother and more reliable.
6. For operational use, much more attention will have to be given to the ALBS system compatibility with the drop aircraft. Particular attention will need to be paid to how the system is restrained against flight loads and how final fore-aft restraint at the time of extraction is achieved.

CONCLUSIONS AND RECOMMENDATIONS

The parachute system developed proved to be a feasible approach for the mid-air deployment of a balloon system; however, further development is required.

Both the radioplane release device (RP-1) and first-stage suspension sling (SS-1) were subject to damage during the deployment of the 28-foot chute.

1. Recommend further development of the first-stage suspension system and the 28-foot chute system to prevent damage to the components of the first-stage suspension system.

Due to a malfunction on Test No. 14, the 42-foot chute opened with a broken centerline; the centerline and snood may not be necessary for reliable 42-foot chute opening.

2. Recommend investigation of elimination of the centerline and snood to aid in the overall simplification of the ALBS system.

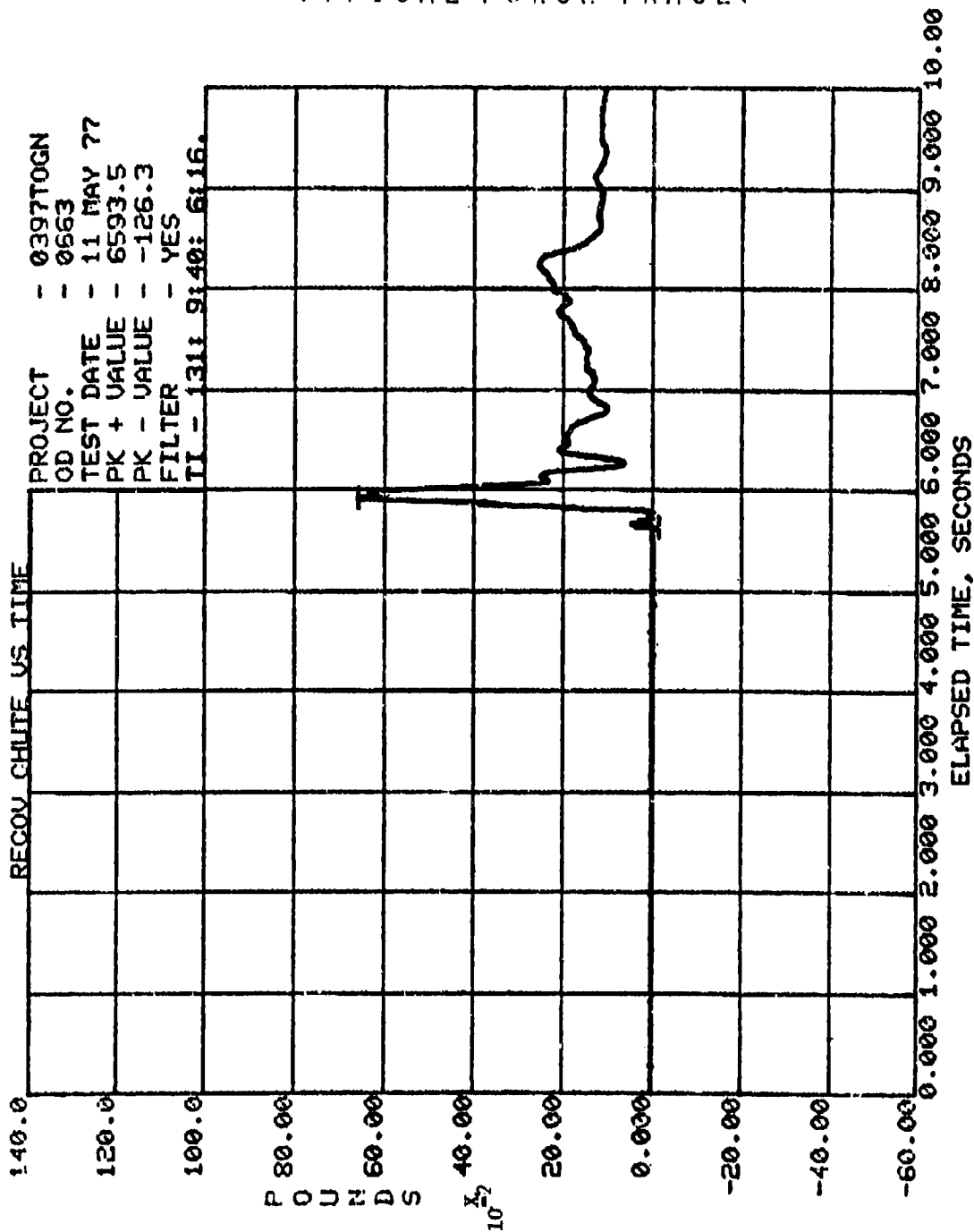
The inflation tube is susceptible to choking from parachute system action and bursting from helium system gas pressures.

3. Recommend that the filler tube be located in an area free of parachute components which could cause it to be choked off and that the tube be strengthened to prevent bursting due to gas pressure.

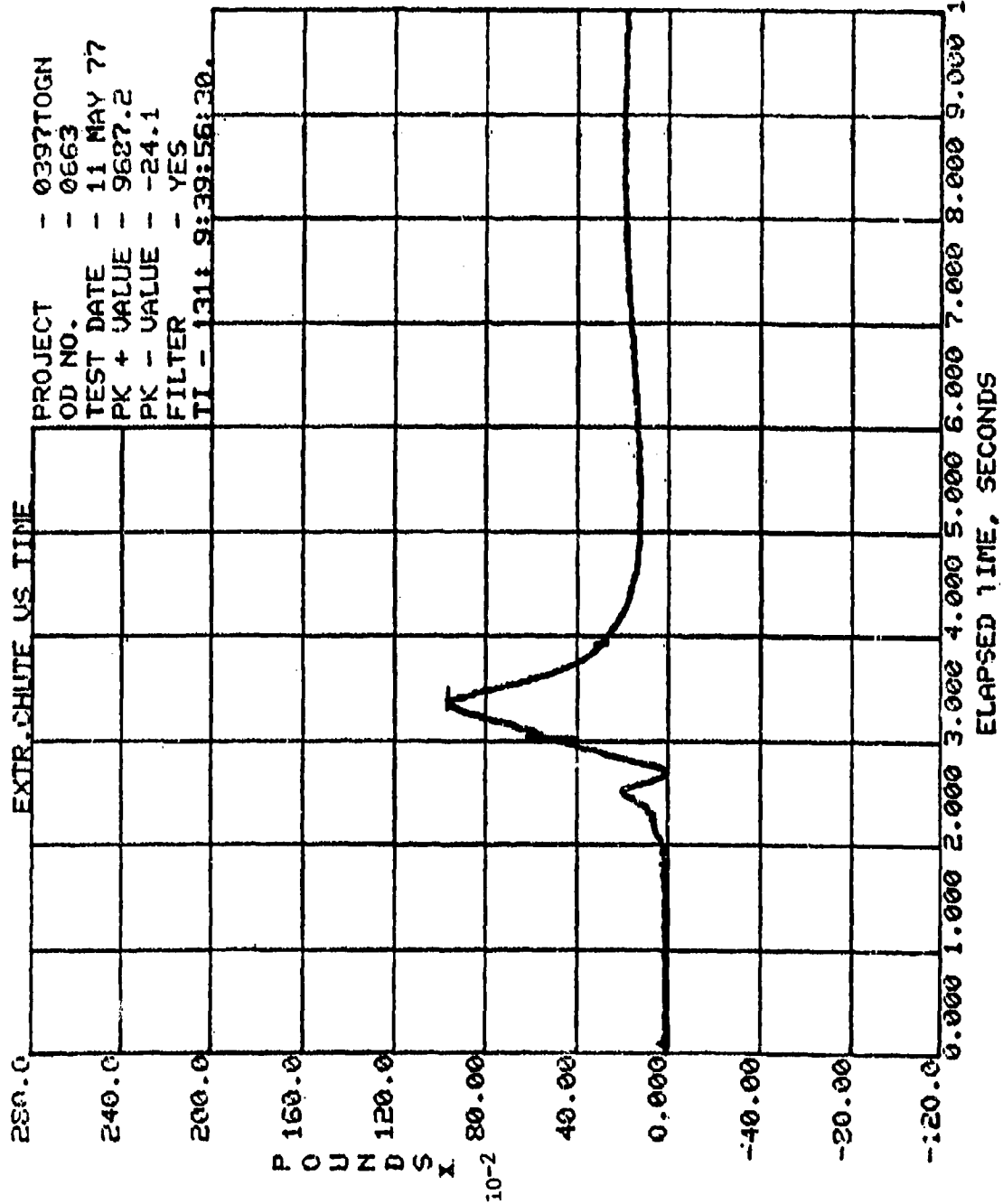
Boldface numerals preceded by an R correspond to the recommendation numbers tabulated in the Conclusions and Recommendations Section of this Report.

APPENDIX A

TYPICAL FORCE TRACES



PROJECT - 0397TOGN
 OD NO. - 0663
 TEST DATE - 11 MAY 77
 PK + VALUE - 9627.2
 PK - VALUE - -24.1
 FILTER - YES
 TI - 1314 9:39:56:30.



APPENDIX B

28-Ft. CHUTE PACKING INSTRUCTIONS

1. Place canopy on a packing table, stretched out under approximately 50 pounds of tension. Place a fan near the canopy skirt to blow air into the canopy while lines are being separated and the canopy folded in accordance with TM/TO-1670-215-23.
2. Attach the deployment bag from a 35-ft D₀ single slot parachute to the cotton loop on the apex of the 28-ft chute by passing the end of a 6-ft length of 4000-lb tubular nylon webbing (FSN 8305-823-7259) through the hole in the center of the deployment bag (inside to out), around the two crossed straps on the bag's end after the straps have been taped with cloth tape, back through the hole in the bag (outside to in), and tie off to the other end of itself so that a 2-ft loop is formed.
3. Tape each 15K connector link (FSN 1670-719-6243) of the 6-legged riser with masking tape.
4. S-fold the canopy into the bag. Close the internal flaps with one turn of single ticket #5 cotton thread (FSN 8310-194-4055) around the suspension lines and through the loops on the bag flaps.
5. Attach the 28-ft chute with a 20K black cap clevis to the 200-ft extraction line. Snug up the sliding keepers against the clevis and tape in place.
6. S-fold the suspension lines, 6-legged riser, and 185 feet of the 200-ft extraction line into the bag. As each stow is made, tie each end of the stow to the bag with one turn of ticket #3 cotton thread (FSN 8310-228-2275). Fifteen feet of extraction line will remain out.
7. Make the bottom bag closing tie with one turn doubled ticket #5 cotton thread by passing one end through the left bottom bag closing loop (top to bottom) behind the extraction line, through the bottom right closing loop (bottom to top), and tie the free ends on top of the extraction line.

8. Using Type I (80-lb BS) cotton tape (FSN 8305-264-2088), close the bag flaps by passing the 80-lb BS tape through each of the eight closing loops located on the closing flaps in such a manner that when the 80-lb BS tape is pulled tight and tied off, then the extraction line is encircled by the bag closing loops.

9. Extend the bag opening safety cord over the bent V-ring. Secure the V-ring with the free end of the pendulum line.



FIGURE B1

STEP #1, FOLDING OF CANOPY



FIGURE B2

STEP #2, BAG ATTACHMENT

B-3



FIGURE B3

STEP #2, BAG ATTACHMENT, CONT'D.

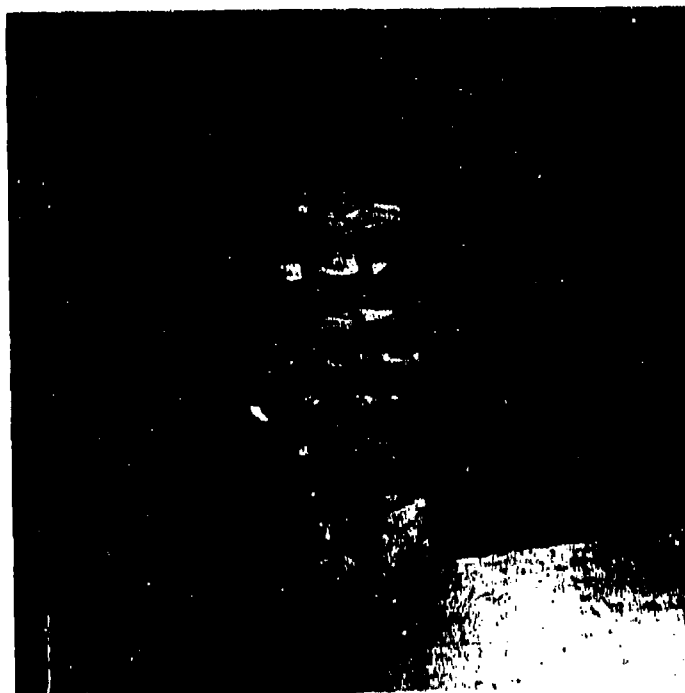


FIGURE B4

STEP #3, TAPED CONNECTOR LINKS



FIGURE B5

STEP #4, S-FOLDED CANOPY IN DEPLOYMENT BAG



FIGURE B6

STEP #4, INTERNAL FLAP CLOSURE
B-5

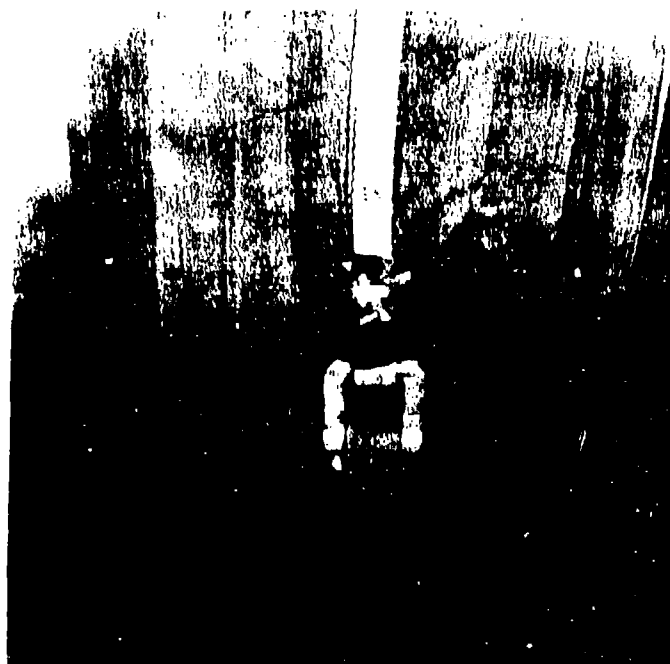


FIGURE B7

STEP #5, BLACK CLEVIS ATTACHMENT



FIGURE B8

STEP #6, S-FOLDING SUSPENSION LINES



FIGURE B9

STEP #6, S-FOLDING 6-LEGGED RISER

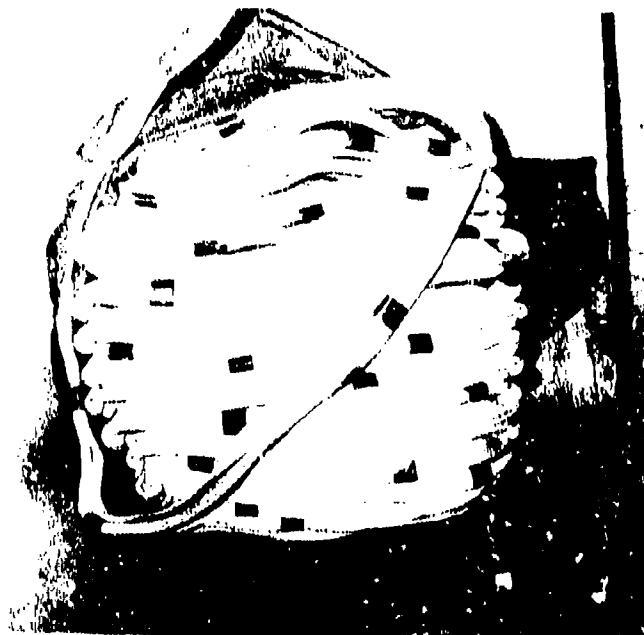


FIGURE B10

STEP #6, S-FOLDING EXTRACTION LINE



FIGURE B11

STEP #8, DEPLOYMENT BAG CLOSURE



FIGURE B12

STEP #9, DEPLOYMENT BAG SAFETY CORD ATTACHMENT
B-8



Fig B13 STEP #9, SECURING BENT V-RING WITH PENDULUM CORD

APPENDIX C

42-FT CHUTE PACKING INSTRUCTIONS

1. Stretch out canopy, air canopy, separate suspension lines (1 & 20 left center, 40 & 21 right center).
2. Install the centerline on a 20K lb cap black clevis.
3. Install the 20K lb cap black clevis and centerline into the apex vent so that the clevis separates apex line 1/21 from line 40/20. The clevis should be oriented so that the clevis bolt can be inserted into the clevis from the line 40 and line 1 side of the apex. Place the remaining suspension lines into the clevis, remembering to pass the clevis through the apex clevis centering loop that is attached to one of the apex lines.
4. Install the non-buffered end of the Type XXIII 50-inch, 12,000-lb nylon webbing centerline extension onto the apex clevis bolt.
5. Pull the centerline and apex down within the canopy so that the apex clevis is just above the middle of the 4th ringsail band. Tie around the canopy in the middle of the 4th band just below the apex clevis with one turn of ticket #5 cotton thread FSN 8310-194-4055.
6. Roll the top of the canopy down to the Ticket #5 cotton thread tie so that the apex clevis is again accessible and the canopy forms a mushroom.
7. Place the rolled portion of the canopy into the snood and, using one turn of Type II 350-lb BS braided nylon (MIL-C-7515), pull the snood very tight around the middle of band 4. The 350-lb BS braided nylon is routed through loops on the snood and through 2 each 4-second reefing line cutters and then tied off around one of the cutters.
8. The centerline extension is routed out of the top of the snood and the apex clevis is tied to each of the four corners of the hole in the snood with a turn of Type I 350-lb BS cotton tape (FSN 8305-260-6915).
9. Lay the inflation tube (in its sleeve) alongside of the chute and tie it with one turn of Type I 350-lb BS cotton tape each location to suspension line 11 as follows:
 - a. One tie at the 15K lb cap connector link.
 - b. One tie at the canopy skirt.
 - c. Two evenly spaced ties between a & b.
 - d. One tie at the gap between ringsail bands 3 & 4.
10. 8-fold the remaining inflation tube alongside of ringsail band 3 until the second tie loop from the upper end of the inflation tube is even with the gap above band 3. Tie each fold of the inflation tube to suspension line 11 at the gaps above and below band 3 with one turn of #5 ticket cotton thread for each fold.

11. Connect the centerline to the 5-legged riser with a 15K 1b cap connector link and tape all links.
12. Tie up slack in each group of suspension lines with one turn of Ticket #3 cotton thread, each location.
13. Using a 20K 1b cap "black" clevis, attach the four legs of SS-2 to the lower end of the 5-legged riser.
14. Lay the black clevis in the center of the main parachute deployment pack and smoothly route a leg of SS-2 out each corner of the pack.
15. Bring 4-feet of the inflation tube out of one corner of the pack and smoothly fold the remaining slack into the side of the pack.
16. Stow the suspension lines, centerline, and inflation tube by folding them back and forth within the pack and tying each stow with Ticket #3 cotton thread.
17. S-fold the canopy into the pack. Center snood.
18. Tie Type II 550-1b BS braided nylon cutter lanyards between the pack stow loops and the pull rings on the two snood reefing line cutters. Leave 6 inches of slack in the lanyards.
19. Safety the pull rings on the cutters to the cutter brackets with one turn of Ticket #3 cotton thread each location.
20. Remove the cutter safety pins.
21. Bring the upper end of the inflation tube out of a pack corner.
22. Close the pack by tying the pack flaps up around the apex clevis with Type III 550-1b cord (FSN 4020-240-2146). This tie will have to be removed after the donut pack is on the main parachute deployment pack and both are within the box.



FIGURE C1

STEPS #2 & 3, 20K-LB CAPACITY BLACK CLEVIS ATTACHMENT ON CENTERLINE

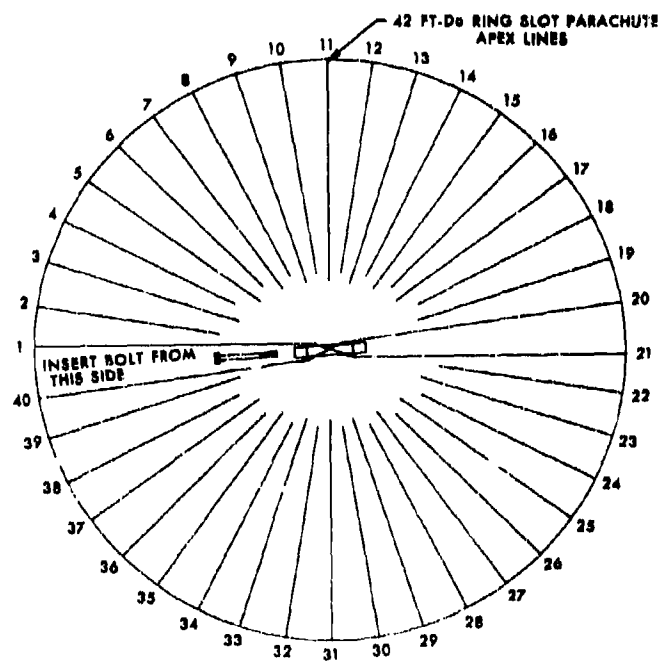


Figure C2. Apex Clevis Installation.

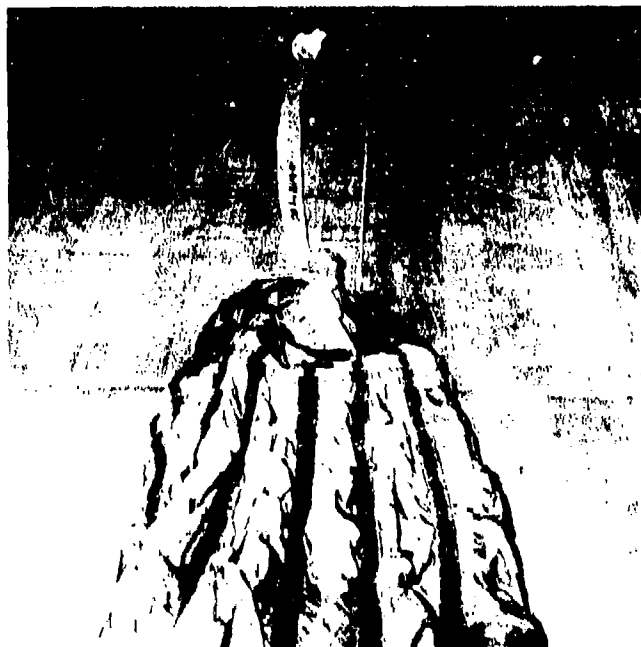


FIGURE C3

STEP #4, CENTERLINE EXTENSION INSTALLATION

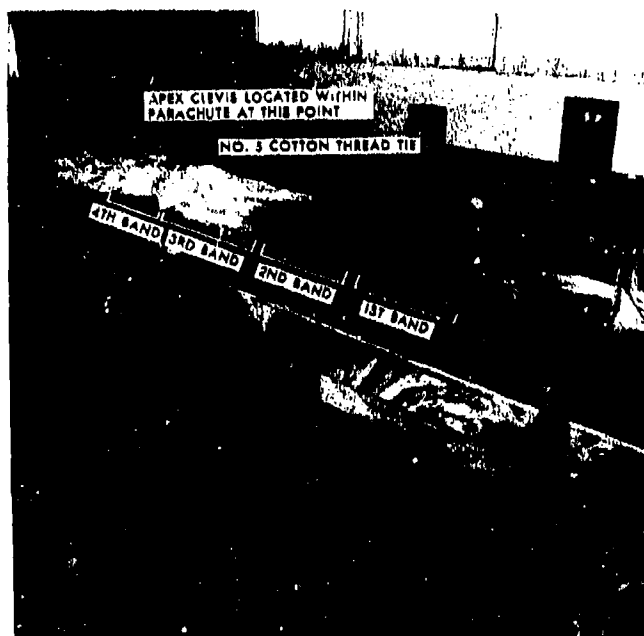


FIGURE C4

STEP #5, CENTERLINE PULLDOWN

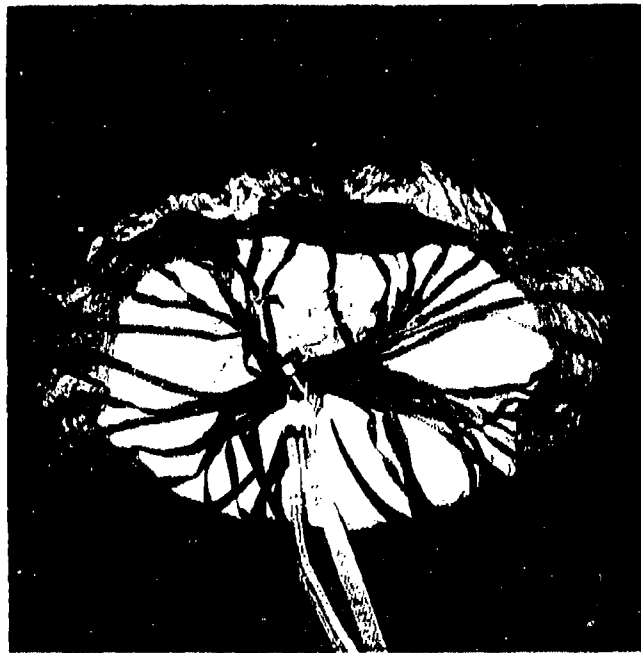


FIGURE C5

STEP #6, CANOPY ROLLDOWN

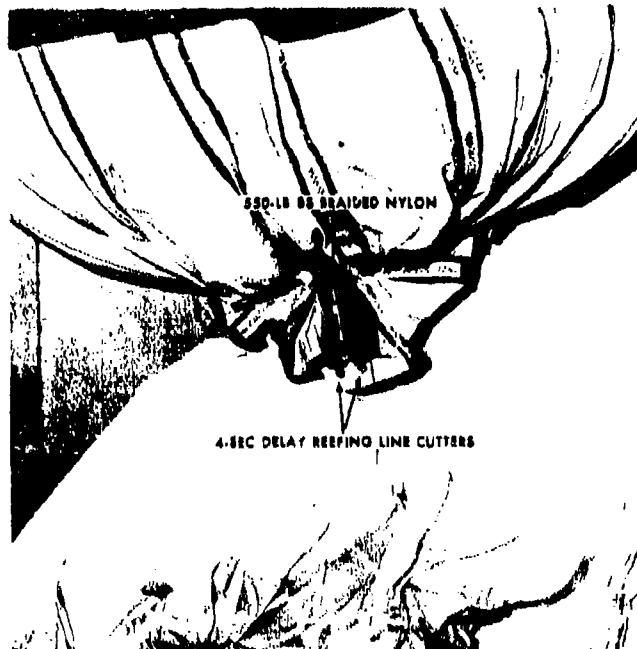


FIGURE C6

STEP #7, SNOOD CLOSE-OFF
C-5

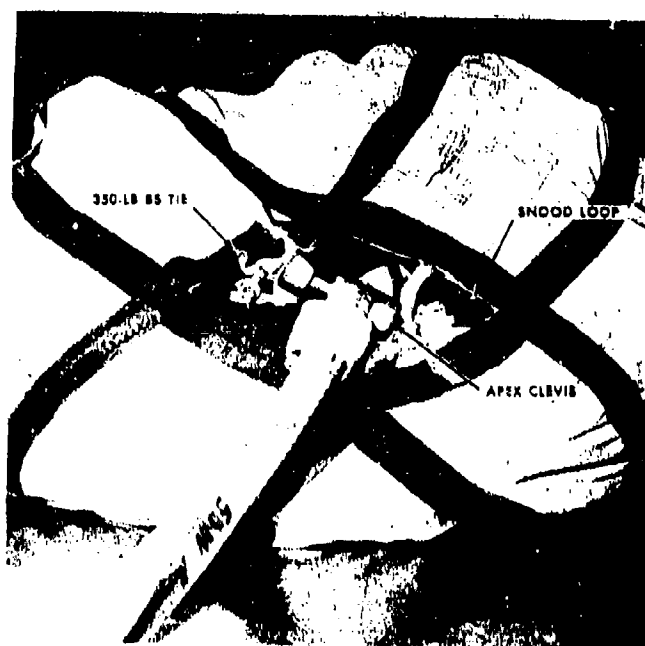


FIGURE C7

STEP #8, 350-LB COTTON WEBBING TIE FROM SNOOD TO APEX CLEVIS



FIGURE C8

STEP #9, INFLATION TUBE ON PACKING TABLE NEXT TO 42-FT D. RS PARACHUTE
C-6



FIGURE C9

STEP #10, INFLATION TUBE ATTACHMENT TO 42-FT D₀ RS PARACHUTE



FIGURE C10

STEP #12, TYING OF SLACK IN SUSPENSION LINES
C-7

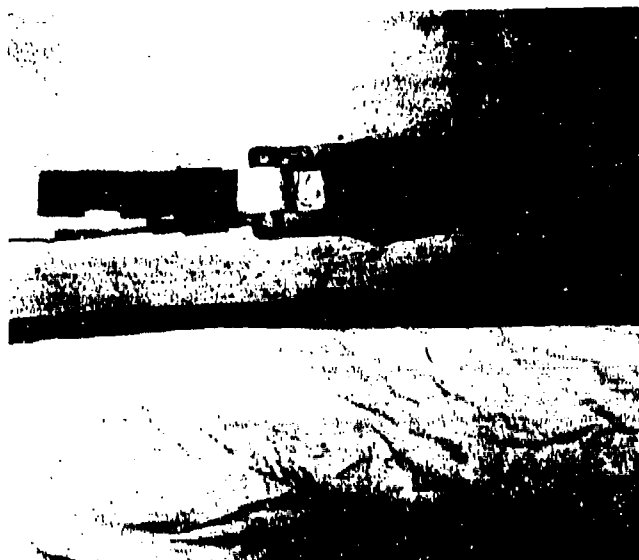


FIGURE C11

STEP #13, SS-2 CONNECTION



FIGURE C12

STEP #14, PLACEMENT OF SS-2 WITHIN DEPLOYMENT PACK
C-8



FIGURE C13

STEP #15, FOLDING OF INFLATION TUBE WITHIN DEPLOYMENT PACK



FIGURE C14

STEP #16, STOWING OF SUSPENSION SYSTEM
C-9



FIGURE C15

STEP #16, STOWING OF SUSPENSION SYSTEM, CONTD.

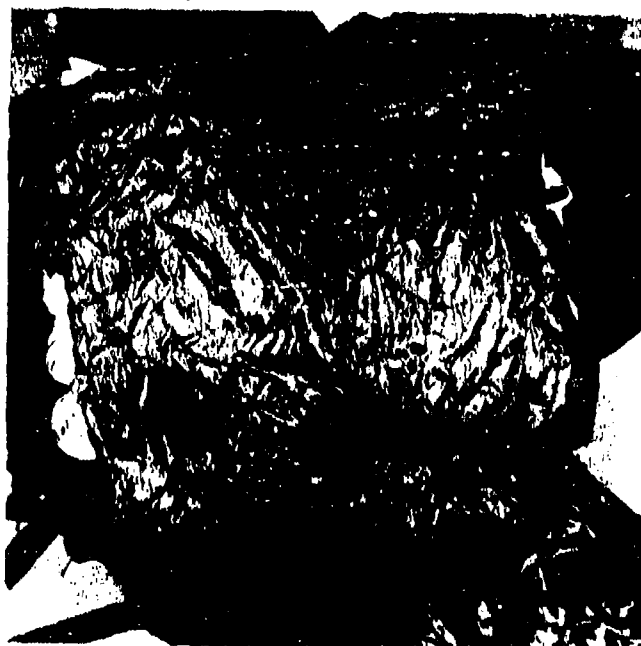


FIGURE C16

STEP #17, FIRST CANOPY FOLD
C-10

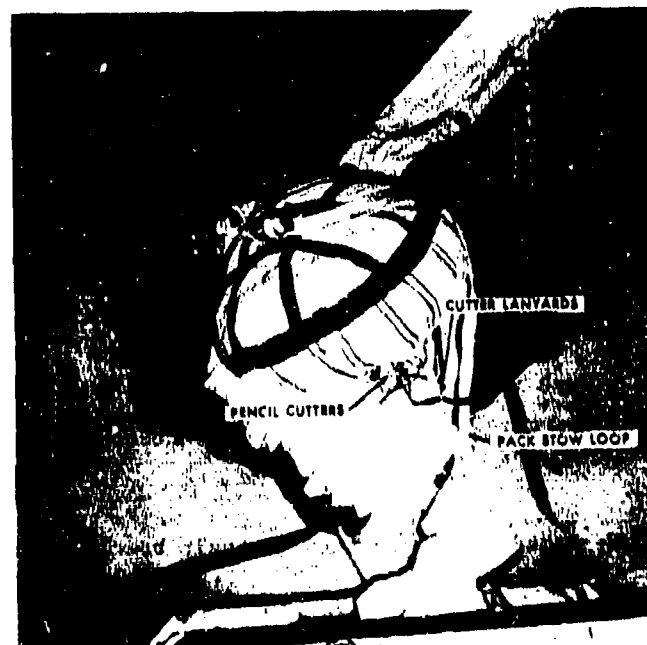


FIGURE C17

STEP #18, LANYARD ATTACHMENT TO SNOOD CUTTERS



FIGURE C18

STEP #22, DEPLOYMENT PACK CLOSURE
C-11

APPENDIX D

DONUT PACKING INSTRUCTIONS

1. Install the non-buffered end of a 6-ft loop of Type XVIII 6000-1b BS nylon webbing (FSN 8305-682-6803) to each end of the swivel. Slide the keepers in place against the swivel and tape.
2. Install 4 each 9-inch straps of Type XVIII 6000-1b BS nylon webbing to the bottom of the donut bag, using 3K-1b cap connector links at the locations provided.
3. Install 4 each 6-second pencil cutters in their brackets on the donut bag cover.
4. Attach the no-twist linkage (NTL) to the bottom end fitting plate so that the sides of the last link are perpendicular to the plane of the mouth of the elbow when the linkage is extended vertically. Mark the edge of the last link closest to the elbow.
5. Lay the balloon flat out along a packing table.
6. Attach the internal inflation tube to the flange on the lower end fitting plate. Use Type III 550-1b BS nylon cord (FSN 4020-240-2146) and filament tape.
7. Bolt the lower end fitting plate to the lower end fitting ring.
8. Attach the upper end of the inflation tube that comes out of a corner of the 42-ft chute pack to the flange on the lower end fitting elbow. First attach the plastic inflation tube and next, the inflation tube sleeve with Type III 550-1b BS nylon cord and filament tape.
9. Place the donut bag on the floor next to the 42 ft chute pack at the end of the table holding the balloon.
10. Place the fabricated cover over the NTL and route the NTL and the reinforced hole in the bottom of the donut bag as the lower end fitting is set

down into the bag. The mouth of the elbow should be facing the side of the bag and the inflation tube is routed up over the side of the bag and to the 42-ft chute pack. A reefing ring attachment loop on the inflation tube sleeve should line up approximately with the upper edge of the donut bag. The inflation tube should not be allowed to become twisted.

11. Stow the balloon into the donut bag. The balloon should remain flat on the table at all times, and any twists that are generated during the stowing process are stowed at the time they are generated. If air within the balloon becomes a problem during the stowing process, loosen the upper end fitting plate and squeeze the air out the top of the balloon. Once the balloon is stowed, retighten the bolts on the upper end fitting.

12. Attach one end of one of the swivel loops to the eye bolt in the upper end fitting.

13. Tie a heavy-duty 3/4-inch reefing ring into the center of a 12-ft length of Type III 550-lb BS nylon cord. Pass the two free ends up through one of the two guide rings located 180° apart on the sides of the donut bag.

14. Lay the donut bag cover onto the donut bag and balloon. Orient the cover so that the reefing line cutters are 90° away from the guide rings.

15. Lace the Type III 550-lb BS nylon cord from the first guide ring around each side of the bag incorporating all rings and reefing line cutters on the inflation tube sleeve, donut bag, and donut bag cover and bring the Type III 550-lb BS cord down out the second guide ring.

16. Tie a 3/4-inch heavy duty reefing ring to the free ends of the Type III 550-lb BS nylon cord at the second guide ring after the lacing has been pulled tight.

17. Pull the center tube of the donut bag up through the center of the donut bag cover and tie the tube to the cover with one turn of ticket #5

cotton thread (FSN 8310-194-4055) four places.

18. Cinch up the bulk of the donut bag by passing a turn of Type IV 1000-lb BS braided nylon cord through each row of loops on the bag and pulling up very tight and tying into a loop.

19. Tie an 85-inch length of Type III 550-lb BS nylon cord to each of the 3/4-inch heavy duty reefing rings at the guide rings. Mark the cords 60 inches out from the rings.

20. Tie 4 each 48-inch lanyards to each of the reefing line cutter activation pins. Safety the lanyards with a turn of ticket #3 cotton thread around the cutter body and through the lanyard knot.

21. Suspend the donut bag over the 42-ft chute pack and pass the Type XXIII 12,000-lb BS nylon webbing centerline extension attached to the 42-ft chute apex clevis up through the center of the donut bag.

22. Place the ends of the 4 each 9-inch straps attached to the bottom of the donut bag over the sides of the 42-ft chute apex clevis.

23. Place the NTL onto the bolt of the 42-ft chute apex clevis. As you are facing the mark placed on the last link of the NTL, the bolt should be passed through the last link from right to left. Tighten the bolt.

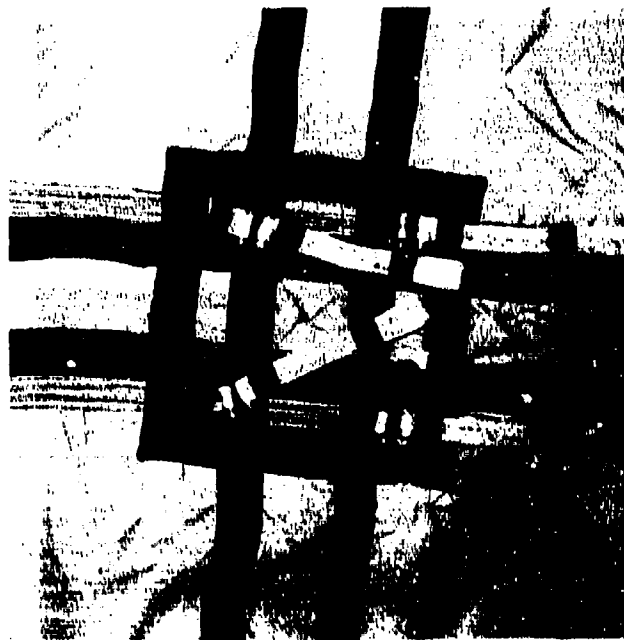


FIGURE D1

STEP #2, INSTALLATION OF ATTACHMENT STRAPS

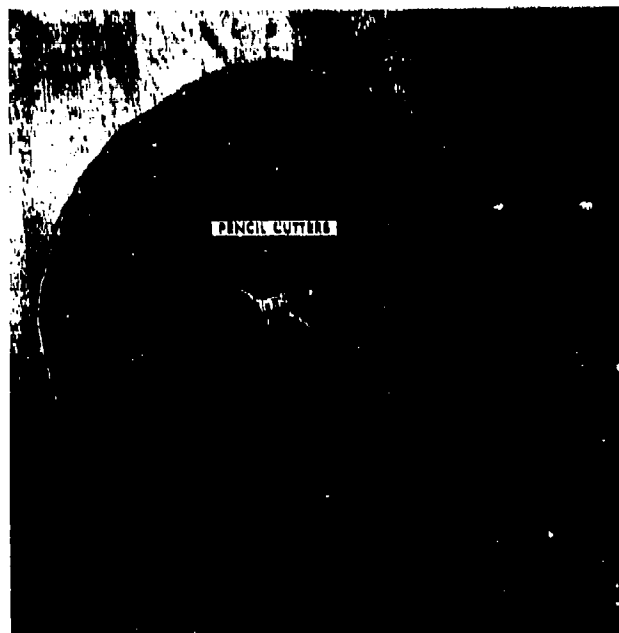


FIGURE D2

STEP #3, PENCIL CUTTER INSTALLATION



FIGURE D3

STEP #4, NTL ATTACHMENT

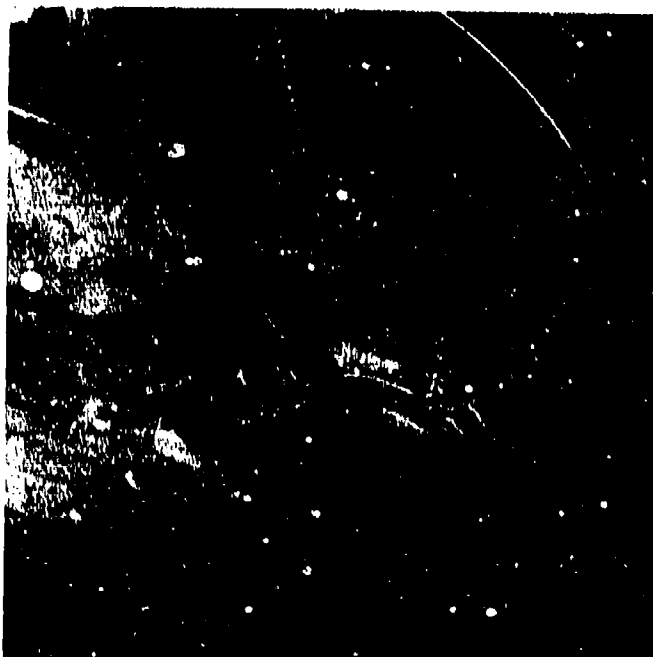


FIGURE D4

STEP #6, TYPE III NYLON CORD TIE



FIGURE D5

STEP #6, FILAMENT TAPE ATTACHMENT



FIGURE D6

STEP #8, ATTACHMENT OF INFLATION TUBE TO ELBOW



FIGURE D7

STEP #8, INFLATION TUBE SLEEVE ATTACHMENT

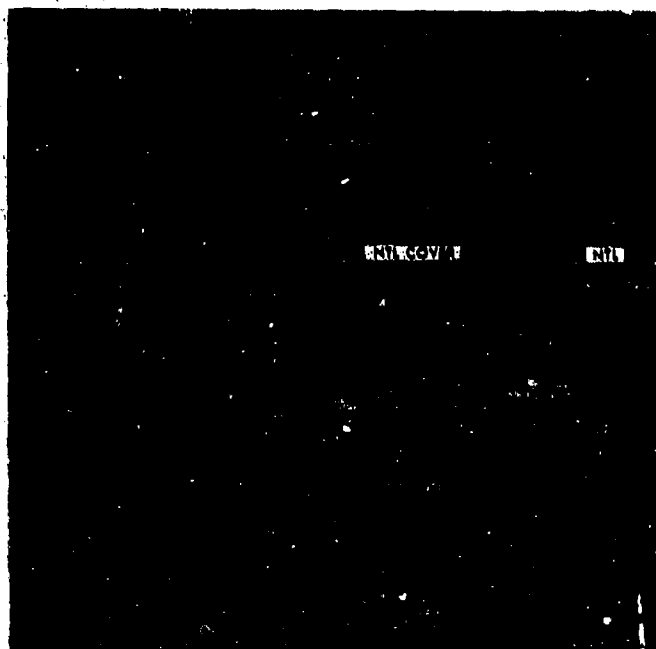


FIGURE D8

STEP #10, PLACEMENT OF COVER OVER NTL

D-7



FIGURE D9

STEP #10, PLACEMENT OF LOWER END FITTING INTO DONUT BAG



FIGURE D10

STEP #11, STOWING BALLOON

D-8



FIGURE D11

STEP #12, ATTACHMENT OF BDL TO UPPER END FITTING

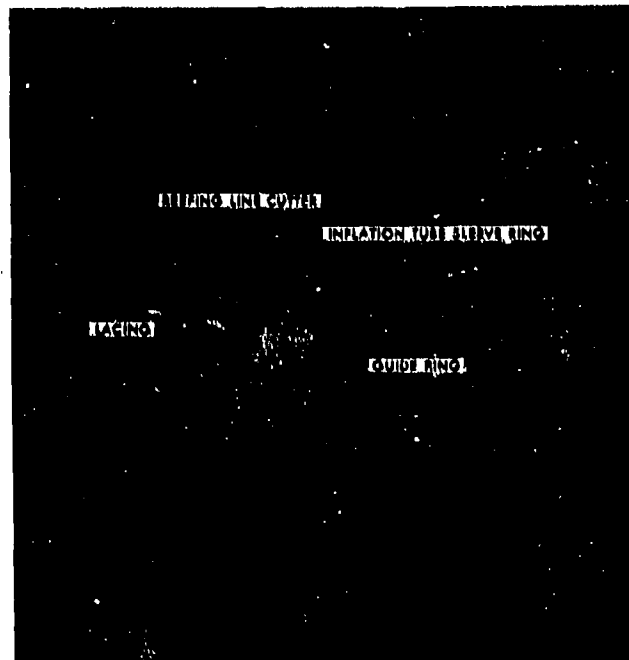


FIGURE D12

STEP #15, LACING OF DONUT BAG

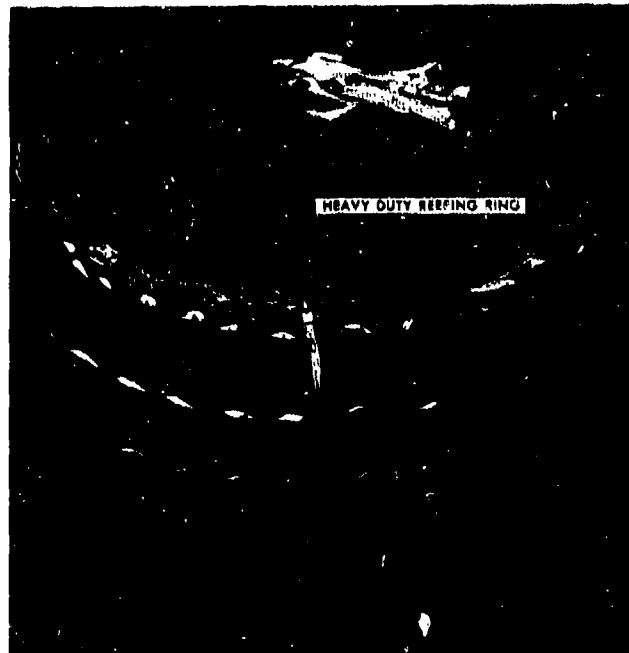


FIGURE D13

STEP #15, LACING OF DONUT BAG, CONTD.

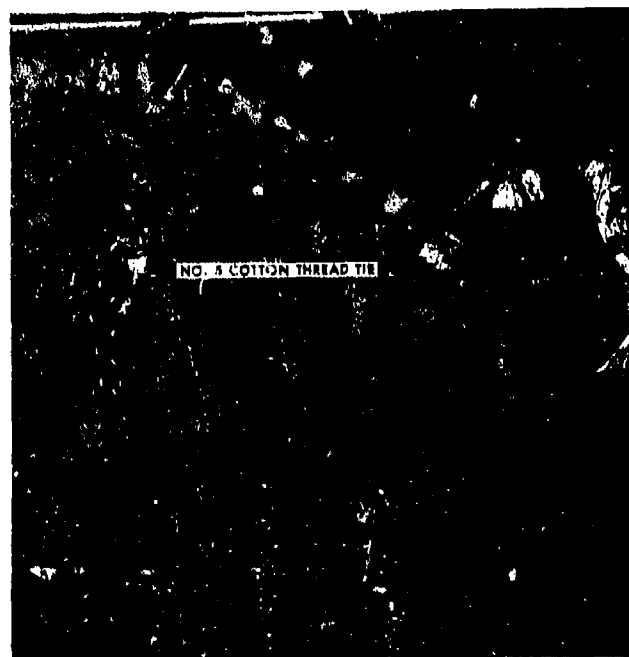


FIGURE D14

STEP #17, CENTER TUBE ATTACHMENT

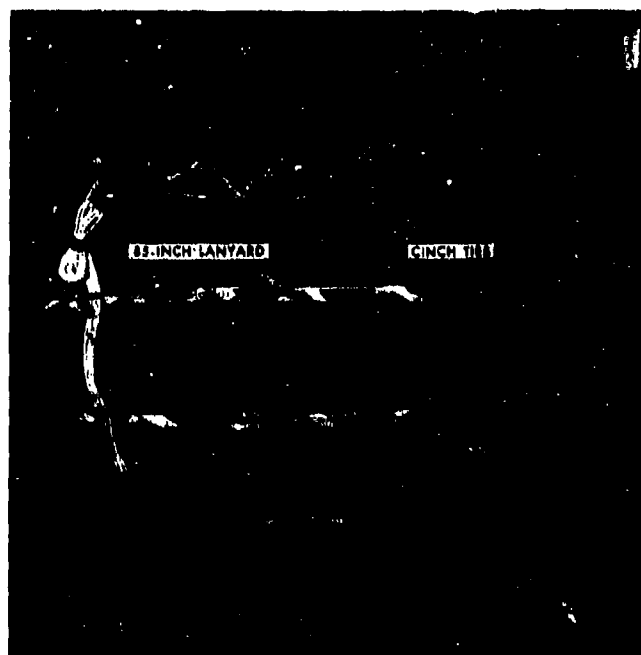


FIGURE D15

STEPS #18 & 19, CINCH TIE AND LACING LANYARD ATTACHMENTS



FIGURE D16

STEP #20, REEFING LINE CUTTER ACTIVATION LANYARD ATTACHMENTS



FIG D17

Steps #21, 22, & 23, ATTACHING DONUT PACK TO 42-FT D₀ RS PARACHUTE

DONUT PACK
D-12

APPENDIX E

ALBS RIGGING INSTRUCTIONS

1. Using the centerline extension as a lift point, lower the 42-ft chute pack and donut bag into the box. Orient the system so that the inflation tube is adjacent to the diffuser to which it connects.
2. Tie the 42-ft chute pack corner loops to the four eyebolts in the box bottom using 1000-lb BS tubular nylon webbing.
3. Remove the Type III 550-lb BS nylon cord (FSN 4020-240-2146) tie which was used to close the pack flaps on step #21 of the 42-ft chute packing instructions.
4. Attach the four each second-stage suspension risers (SS-2) coming out of each corner of the 42-ft chute pack to their respective 15K-lb capacity connector link at the outside corners of the box. Tie each SS-2 to the bar adjacent to the 15K-lb capacity connector link with one turn of Type I 80-lb BS cotton tape. Each SS-2 should be smoothly routed (no twists) from down within the pack up to the link. Tape the slack in SS-2 to the box wall.
5. Tie one end of four each 6-ft lengths of 1000-lb BS tubular nylon webbing to the four eyebolts in the box bottom.
6. Prepare a pull knife by sharpening it, safetying it with a core strand from Type III 550-lb BS nylon cord, and tying a 3-ft-long 1000-lb BS tubular nylon webbing lanyard to it.
7. Pass the free end of the 1000-lb BS tubular nylon webbing from one eyebolt through the prepared pull knife and tie the end around the 1000-lb BS tubular nylon webbing coming from the opposite eyebolt. Cinch down the loop formed over the top of the donut bag very tight and tie off and safety the cinch knot.

8. Repeat step 7 for the remaining two lengths of 1000-lb BS tubular nylon coming from the eyebolts. An "X" should be formed over the donut bag with the pull knife at the center. The side of the box which contacts the aircraft roller conveyors (when the box is horizontal in the aircraft) will be designated as the front of the box when the box is vertical.

9. Prepare the first-stage suspension system as follows:

a. Onto the bell end of a G-12 clevis, place the D rings of 4 each first-stage suspension slings (SS-1).

b. Onto the bolt end of the same G-12 clevis, place a 14-inch Type XXVI nylon webbing strap. Tape the strap to the center of the bolt with cloth tape. Tape the bolt and nut to prevent unscrewing.

c. Place a 20K-lb capacity J-1 clevis onto the bell end of the G-12 clevis between the center two D rings. Attach a 14-inch Type XXVI nylon strap to the bolt end of the J-1 clevis. Tape the bolt and nut to prevent unscrewing. Attach the bolt end of a radioplane release device (RP-1) to the free end of this 14-inch strap. Tape the bolt and nut.

d. Suspend the G-12 clevis over the box center with the gun adapter block on RP-1 facing forward.

e. Pass each of the free ends of SS-1 through the inner 15K-lb capacity connector links on each box corner. The lines pass from the outside of the link to the inside and should have no twists in them.

f. The free ends of SS-1 are then orderly placed onto the swing pin of the RP-1 and the RP-1 is closed and locked with a cotter pin. SS-1 should have no twists in any of its legs. Tie around the SS-1 at RP-1 with one turn of ticket #5 cotton thread (FSN 8310-194-4055).

g. Raise the G-12 clevis until the slack is out of SS-1 and tack each leg of SS-1 at the 15-K-lb capacity connector links with one turn of ticket

#5 cotton thread.

h. Place a 20K-lb capacity J-1 clevis onto the right side of the G-12 clevis and attach the main parachute deployment line (MPDL) to the bolt end of the J-1 clevis. Attach the end of the MPDL which does not have the small lanyard attachment loops. The free end of the MPDL passes down between the right front and right rear legs of SS-1. Tape the J-1 clevis bolt.

i. Lower the G-12 clevis and tie the bolt end of the G-12 clevis to the middle of the bar at the top rear of the box. Use one turn of Type I 80-lb BS cotton tape two places.

10. Tape all sharp edges on the diffuser and pull the end of the plastic inflation tube 8 inches over the end of the diffuser and tape in place with cloth tape.

11. Pull the inflation tube sleeve over the end of the diffuser and secure in place with a hose clamp. Secure the upper end of the diffuser to the box wall using a wooden spacer block between the diffuser and the wall and a turn of 1000-lb BS tubular nylon webbing around the diffuser and tied through holes in the box wall.

12. Turn the box down on its face.

13. Tie the left side legs of SS-1 to the center of the left vertical pipe with 1 turn of Type I 80-lb BS cotton tape two places.

14. Repeat step #13 for the right side.

15. Tie the MPDL to the right side of the bottom pipe with one turn of Type I 80-lb BS cotton tape.

16. Tie the MPDL to the right side of the top pipe with two turns of Type I BS cotton tape.

17. Attach the end of the MPDL to the bolt end of a radioplane release device (RP-2) and tape the bolt.

18. Attach the Type XXIII 12,000-lb nylon webbing centerline extension coming from the center of the donut bag to the swing pin of RP-2. Close RP-2 and insert the cotter pin.

19. Tie the RP-2 to the bottom wall of the box with one turn of Type J 80-lb BS cotton tape.

20. Attach the end of the balloon deployment line (BDL) coming out of an edge of the donut bag to the MPDL. Use a 15K-lb capacity connector link and make the connection to the MPDL loop that contains the RP-2 bolt. S-fold the slack in the BDL and tie out of the way with a turn of ticket #5 cotton thread two places.

21. Tie the MPDL to the center of the bottom pipe with one turn of Type I 80-lb BS cotton tape.

22. Double back the MPDL to RP-2 and tie it to itself with 2 turns of Type I 80-lb BS cotton tape.

23. Locate the four lanyards from the reefing line cutters on the donut bag cover. Tie two of the four lanyards to each of the lanyard loops on the MPDL, leaving 3-4 inches of slack in each lanyard.

24. Tie the pull knife lanyard (step #6) to one of the lanyard loops on the MPDL, leaving 12 inches of slack.

25. Tie two each lacing lanyards (step #18 of donut packing instruction) at the location marked on the lanyards to the 15K-lb capacity connector link that the BDL is connected to. S-fold the slack together and tape to the bottom box wall.

26. Tie a Type III 550-lb BS nylon cord lanyard from the MPDL lanyard loop to the pull pin used to activate the helium system timer. Safety the timer pull pin with one turn of ticket #5 cotton thread. Leave 6 inches of slack in the lanyard.

27. Double back the 14-inch strap between RP-1 and the J-1 clevis and tie the RP-1 bolt to the J-1 clevis bolt two places using one turn of Type IV 750-lb BS nylon cord with efficiency knots. Tie RP-1 and the J-1 clevis together as close as possible.
28. Using one turn of Type I 80-lb BS cotton tape tie SS-1, RP-1, and the MPDL together.
29. Prepare RP-1 and RP-2 by installing into each radioplane release device the following:
- a. 2 each #2 booster capsules.
 - b. 2 each 10-second delay cartridges (NSN 1377-00-060-0886).
 - c. 2 each firing assemblies with safety pins.
 - d. 2 each 2-ft 1000-lb BS tubular nylon activation lanyards.
30. Install a 3K-lb capacity connector link (FSN 1670-217-2421) in the MPDL just above the sewn keeper in the doubled back portion of the MPDL. Tape around the MPDL above the link to keep the link in place.
31. Tie RP-2 activation lanyards to the 3K-lb capacity connector link, leaving 1-2 inches slack.
32. Tie the RP-1 activation lanyards to the J-1 clevis, leaving 1-2 inches slack.
33. Attach the free end of the extraction line coming from the 28-ft chute pack to the 14-inch strap on the G-12 clevis bolt, using a 20K-lb capacity black clevis. Tape over the clevis, extraction line, and strap.
34. Glue 3 layers of paper honeycomb to the box's bottom.

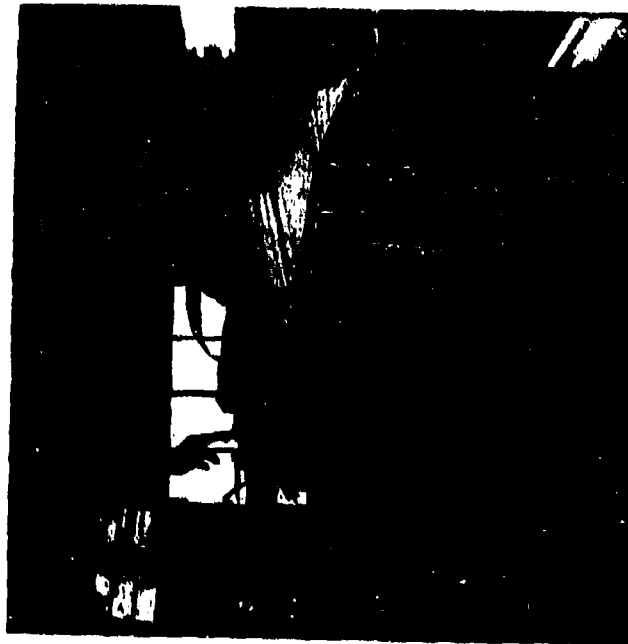


FIGURE E1

STEP #1, LOWERING SYSTEM INTO BOX



FIGURE E2

STEP #4, ATTACHMENT OF SS-2 TO LINK AND TO BAR

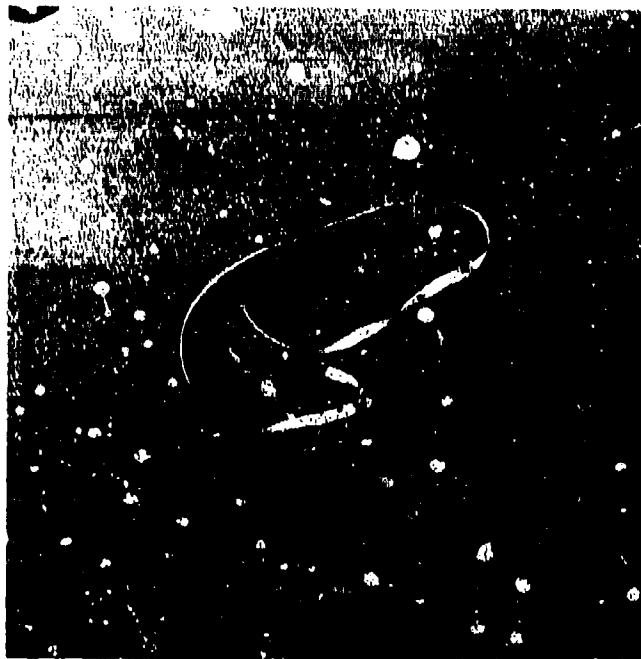


FIGURE E3

STEP #6, PREPARATION OF PULL KNIFE



FIGURE E4

STEPS #7 & 8, DONUT BAG AND 42-FT D.O. RS PARACHUTE PACK RESTRAINT TIE INSTALLATION

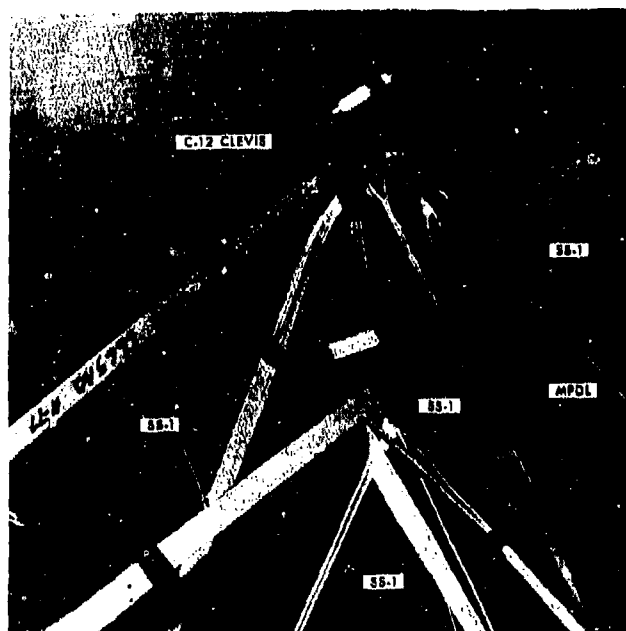


FIGURE E5

STEPS #9a,c,e, PLACEMENT OF SS-1, AND MPDL ON G-12 CLEVIS

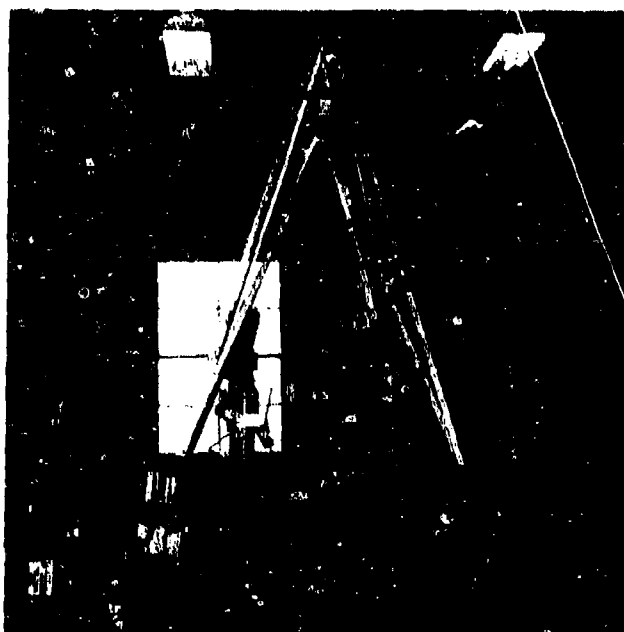


FIGURE E6

STEP #9g, STRETCHING SS-1 OVER BOX
E-8



FIGURE E7

STEP #9g

TACKING SS-1 AT 15K-LB CAPACITY CONNECTOR LINK

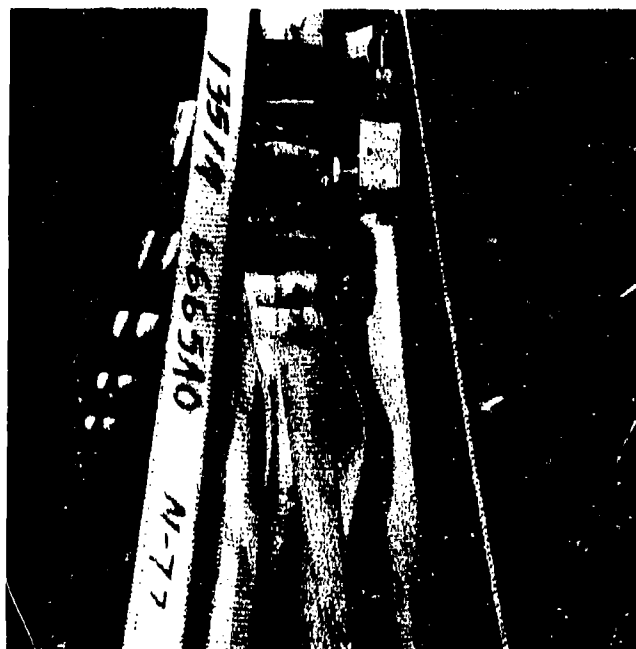


FIGURE E8

STEP #9f, TACKING SS-1 AT RP-1

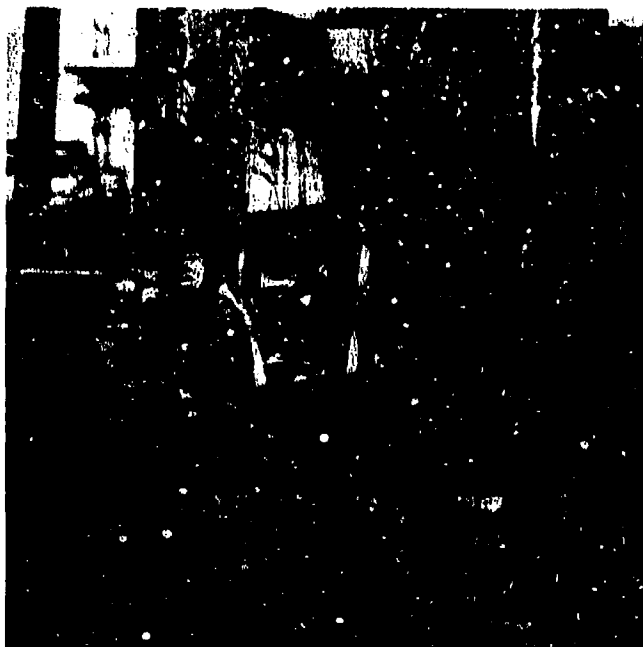


FIGURE E9

STEP #91, 80-LB BS COTTON TAPE TIES BETWEEN G-12 CLEVIS AND BAR OF BOX



FIGURE E10

STEP #11, ATTACHMENT OF INFLATION TUBE TO GAS DIFFUSER
E-10

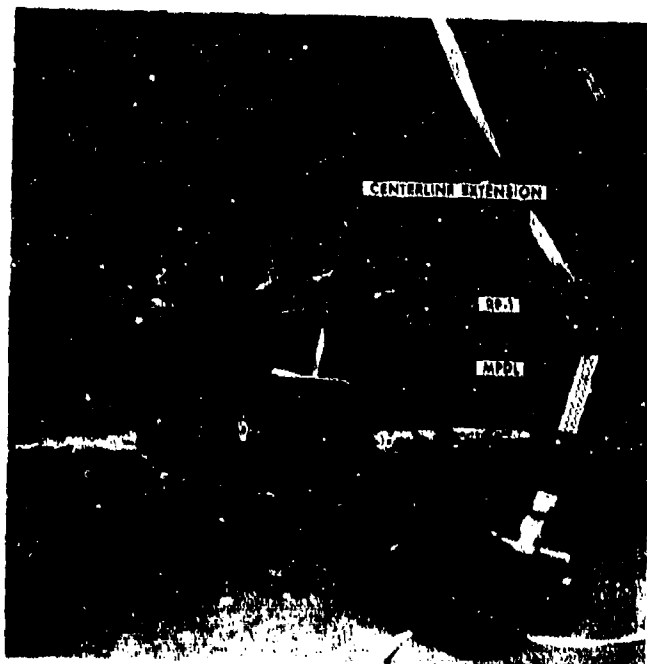


FIGURE E11

STEP #15, RP-2 ATTACHMENT



FIGURE E12

STEP #20, ATTACHMENT OF BDL TO MPDL
E-11



FIGURE E13

STEP #25. LACING PULLING LANYARDS ATTACHED TO 15K-LB CAPACITY CONNECTOR LINK ON BDL



FIGURE E14

STEP #31, MPDL FOLDBACK WITH AN 80-LB BS COTTON TAPE TIE. RP-2 ACTIVATION LANYARDS ARE ATTACHED TO THE 3K-LB CAPACITY CONNECTOR LINK.



FIGURE E15

STEPS #23,24,26, LANYARD ATTACHMENTS TO MPDL (4 EA REEFING LINE CUTTER LANYARDS, 1 EA HELIUM SYSTEM TIMER LANYARD, AND 1 EA PULL KNIFE LANYARD)

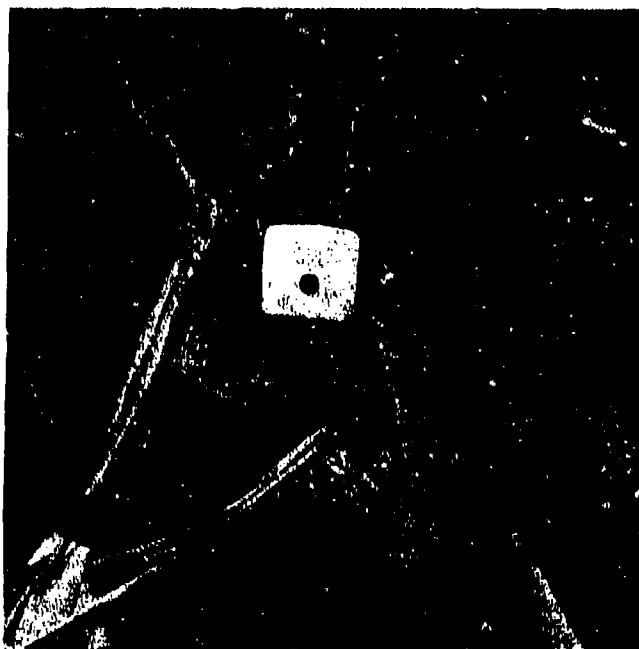


FIGURE E16

STEP #28, RP-1 FOLDBACK WITH AN 80-LB BS COTTON TAPE TIE AROUND SS-1, AND MPDL
E-13

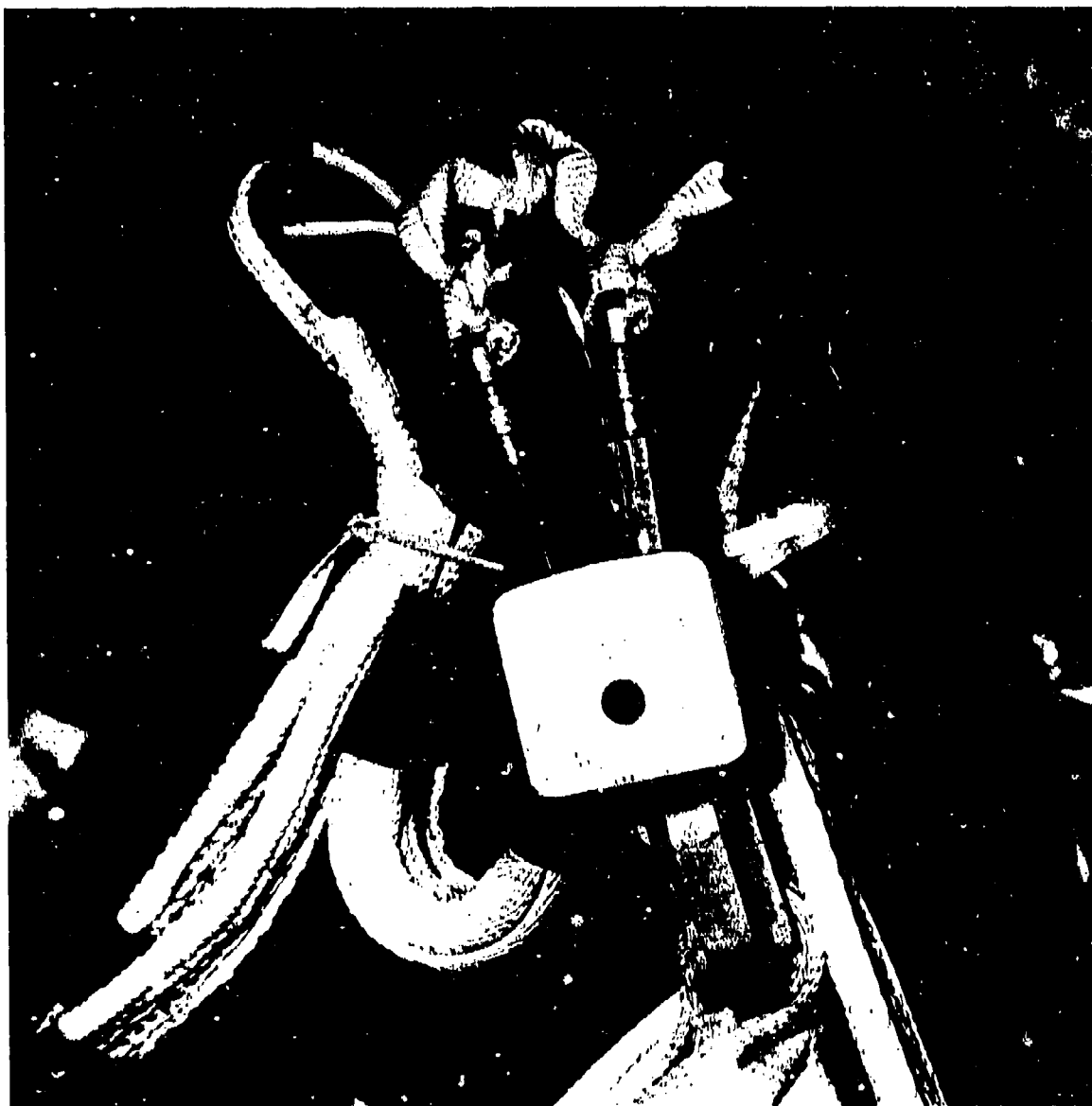


Fig E17

RP-1 ACTIVATION LANYARDS (Step #27)

APPENDIX F

ALBS RIGGING COMPONENTS

1. Deployment bag (35-ft D₀ single slot bag, ASD DN X68J374).
2. 28-ft D₀ ring slot parachute (1670-687-5459).
3. 20,000-lb "black" clevis (66B-1405, 66C-1406, 66B-1407).
4. Drogue line, 200-ft 2-ply Type 23 (12,000-lb) nylon webbing, MIL-W-4088.
5. 20,000-lb G-12 clevis (1670-587-3421).
6. 20,000-lb J-1 clevis (FSN 1670-360-0300).
7. 14-inch 2-ply Type 26 (15,000-lb) untreated nylon webbing, MIL-W-4088 (FSN 8305-177-5069).
8. First stage, MIL-W-4088, radioplane release device (DN65E-1357), 20,000-lb capacity lanyard-activated, ten-second delay (NSN 1377-00-060-0886). Activation lanyard attached to item 6.
9. First stage suspension sling; 4 legs, 138 inches long, 1 ply, Type 18 (6,000-lb) nylon webbing each leg (FSN 8305-682-6803).
10. Main parachute subsystem deployment line, 2-ply Type 19 (10,000-lb) nylon webbing (FSN 8305-823-7257).
11. 15,000-lb connector link, 1 each corner (FSN 1670-719-6243).
12. 4x4x4-ft box.
13. Helium subsystem protected with 6 layers paper honeycomb (FSN 1670-753-3928).
14. Activation lanyards, 4 each, Type III, 550-lb braided nylon cord (4020-240-2146); activated 4 each 6-second delay pencil cutters on donut pack cover to cut lacing line holding pack cover onto donut pack.
15. Pull knife (DN 77B1742) and 1500-lb tubular nylon lanyard (8305-641-5599); cuts restraint ties holding donut pack and 42-ft D₀ ring sail parachute deployment pack in box.
16. Activation lanyards for item 18, 2 each 1500-lb tubular nylon (8305-641-5599) attached to item 10 with a 3000-lb connector link (1670-747-7541).
17. 15,000-lb connector link (1670-719-6243) to attach items 19, 20, and 21 to item 10.
18. Second stage-radioplane release device DN 65E-1357, 20,000-lb capacity lanyard activated, ten-second delay (FSN 1377-00-060-0886).

19. Activation lanyard for 25-second delay helium subsystem timer, Type III, 550-lb braided nylon cord (4020-240-2146).
20. Balloon deployment line, 2-ply Type 18 (6,000-lb) nylon webbing (8305-682-6803).
21. Lacing lanyards, Type III, 550-lb braided nylon cord (4020-240-2146), 60 inches long; used to pull out the lacing holding the donut bag cover onto the donut bag.
22. Centerline extension, 2-ply, Type 23 (12,000-lb) nylon, MIL-W-4088.
23. Donut pack for containing the balloon:
 - a. Donut pack cover
 - b. Donut pack sides and bottom
24. Polyethylene inflation tube with cotton sleeve.
25. Snood.
26. Snood closure tie, Type III, 550-lb braided nylon cord (4020-240-2146) with each 4-second pencil cutters.
27. Electrical cable, contractor-furnished.
28. 350-lb cotton webbing (8305-260-6915), 1 turn each location.
29. 42-ft D₀ ring sail parachute (Pioneer Co. PN X7111018-1).
30. Centerline.
31. 15,000-lb connector link, 5 pieces (FSN 1670-719-6243).
32. 5-legged adapter.
33. 20,000-lb "black" clevis (DN 66B-1405, 66C-1406, 66B-1407).
34. Second stage suspension straps.
35. 15,000-lb connector link, 1 each corner (FSN 1670-719-6243).
36. Swivel.
37. 157,000-ft³ balloon, contractor-furnished:
 - a. Perforated polyethylene sleeve one-third the balloon length long.
38. Lower end fitting elbow.
39. Tenney release device, contractor-furnished.
40. 20,000-lb "black" clevis (DN 66B-1405, 66C-1406, 66B-1407).
41. No-twist links.

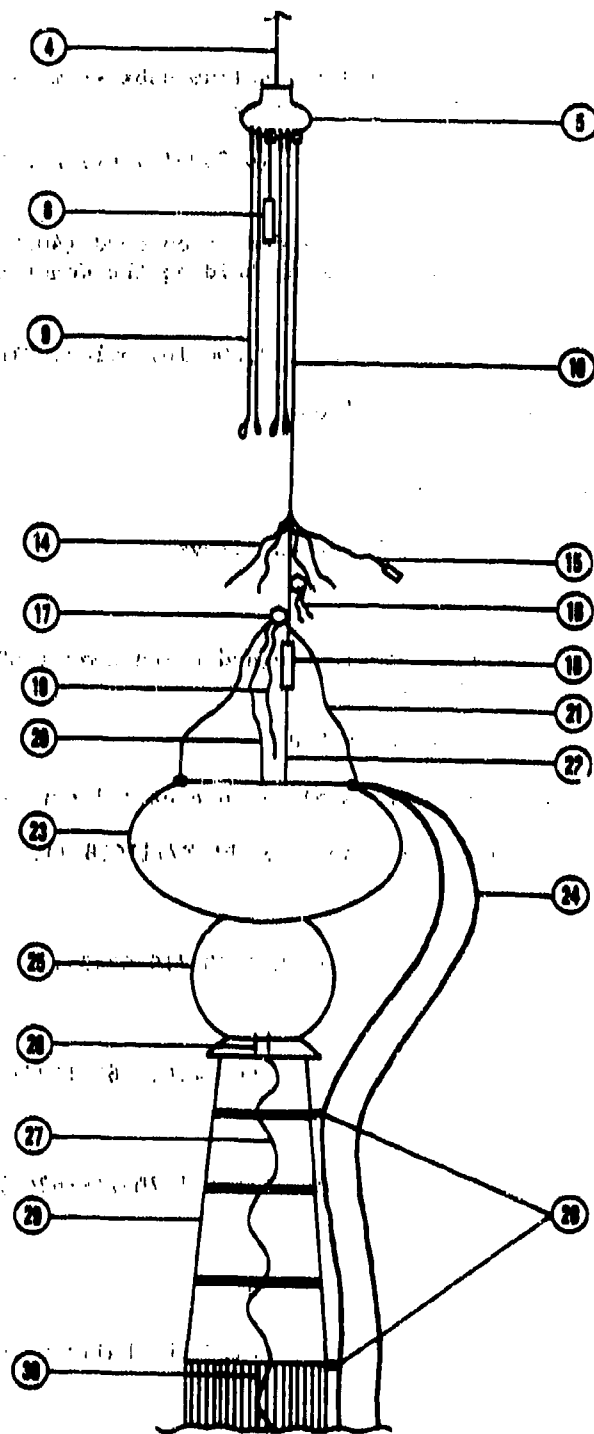


Figure F2, ALBS Rigging Components.

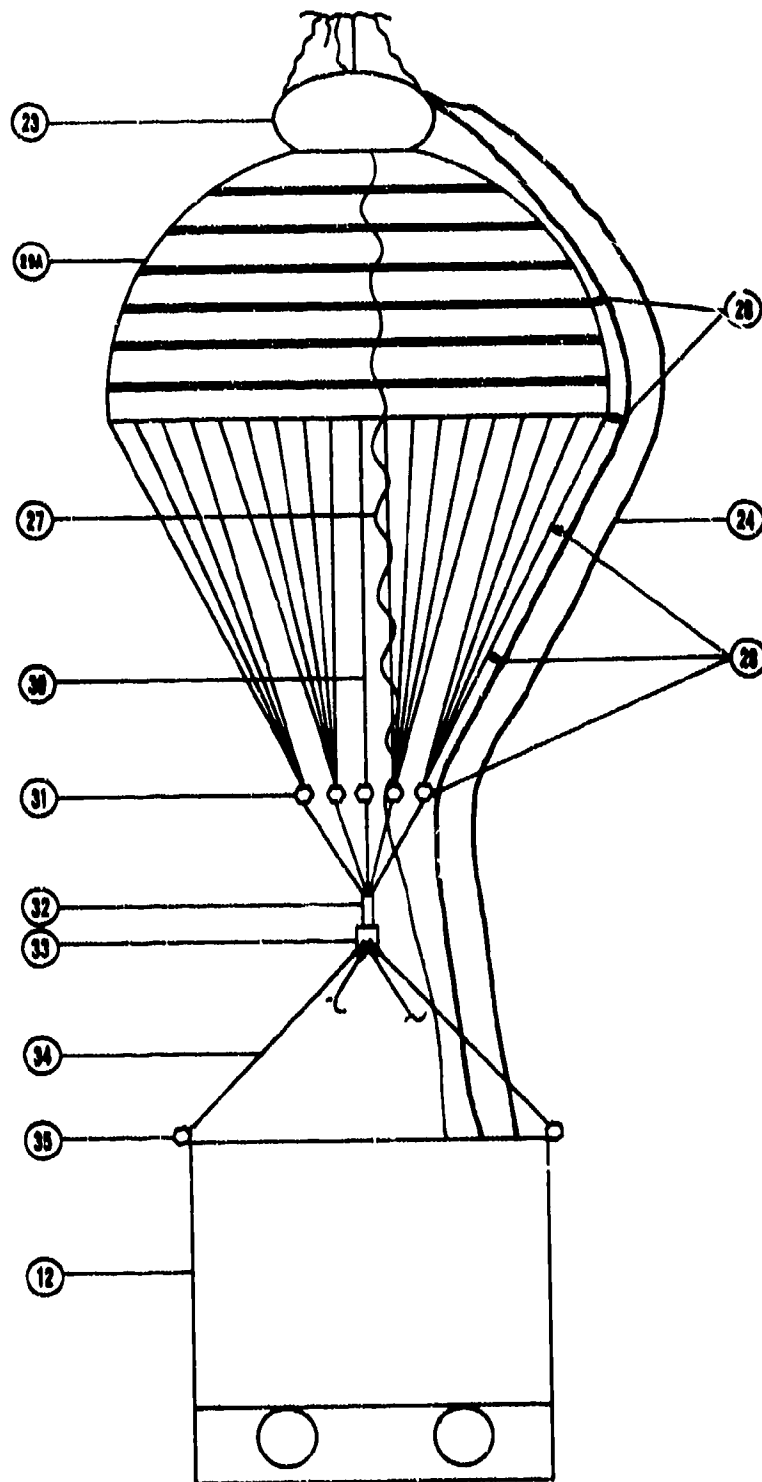


Figure F3. ALBS Rigging Components.

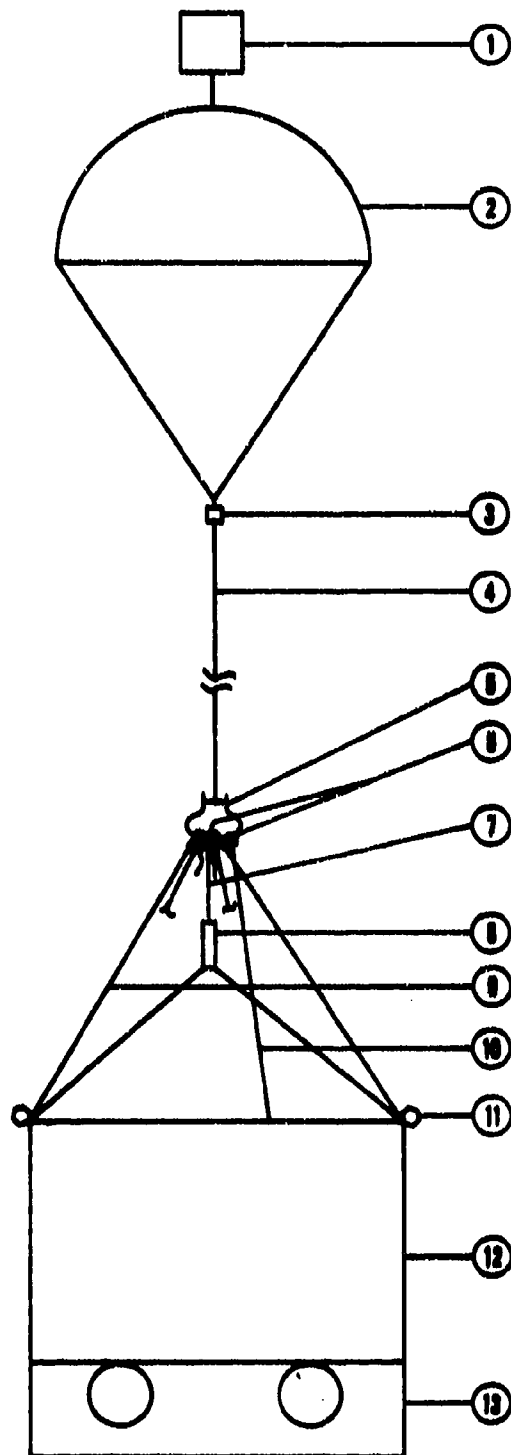


Figure F1. ALBS Rigging Components.

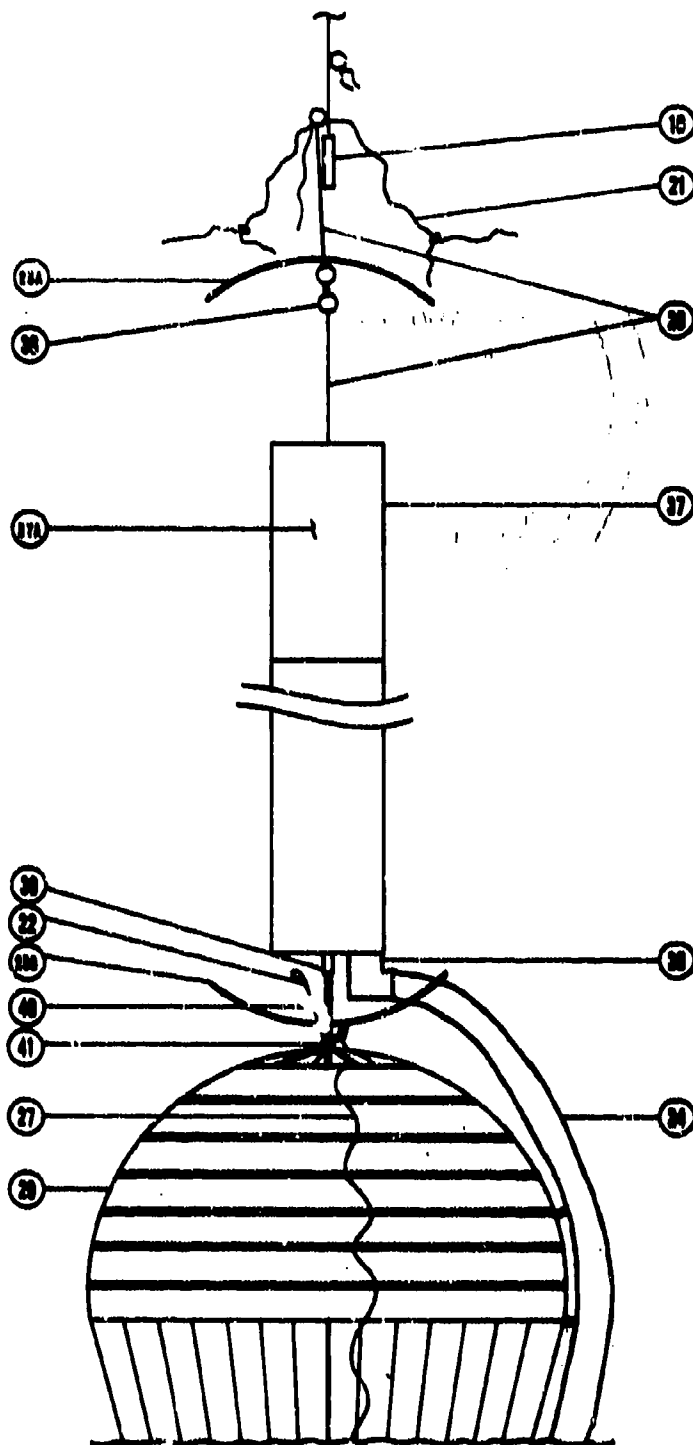


Figure F4. ALBS Rigging Components.

LIST OF ABBREVIATIONS AND SYMBOLS

ALBS	Air-Launched Balloon System
ASD	Aeronautical Systems Division, Wright-Patterson AFB, OH
BDL	Balloon deployment line
BS	Breaking strength
Cap	Capacity
DN	Drawing number (NOTE: All drawing numbers refer to 6511th Test Squadron drawings, unless otherwise stated.)
D _o	Nominal diameter
FSN	Federal stock number
Ft	Feet
K	Thousand
Lb	Pound
MPDL	Main parachute deployment line
NSN	National stock number
NTL	No-twist linkage
RP	Radioplane release device
SS1	First-stage suspension slings
SS2	Second-stage suspension slings